Climate Change : A Burning Issue For The World

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Preface

We have great privilege in presenting this book entitled as Climate Change: A burning issue for the world. Climate change is an issue that must be simultaneously tackled at all scales, by all parts of society. It is likely, for example, to challenge the realization of sustainable development, including the Millennium Development Goals, by reducing the livelihood assets of vulnerable people and by impacting on natural resources.

The issues of climate change and biodiversity are interconnected, not only through climate change effects on biodiversity, but also through changes in biodiversity that affect climate change. Conserving natural terrestrial, freshwater and marine ecosystems and restoring degraded ecosystems (including their genetic and species diversity) is essential for the overall goals of the UNFCCC because ecosystems play a key role in the global carbon cycle and in adapting to climate change, while also providing a wide range of ecosystem services that are essential for human well-being and the achievement of the Millennium Development Goals.

This book is focus on the impact of Climate change and its effect near-term future. In some cases, key results are reported out to 100 years to provide a larger context but the emphasis is on the next 25-50 years. This nearer term focus is chosen for two reasons. First, for many natural resources, planning and management activities already address these time scales through the development of long-lived infrastructure, plant species rotation, and other significant investments. Second, climate projections are relatively certain over the next few decades.

15 March 2020
Republic Day

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Taken as a whole, the range of published evidence indicates that the net damage costs of climate change are likely to be significant and to increase over time.

- Intergovernmental Panel on Climate Change

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Besides, she is also a member of several scientific and professional bodies like Indian Physiological Society, International Society for Environmental Botanists, Omics Group of Conferences, Indian Plant taxonomy Association, Delhi University Women Association and Delhi University of Botanical Society.

She has been facilitated many national as well as International organizations during the conferences, seminars, congresses and conventions where she has presented her paper on relevant and contemporary scientific and technical issues.

Prof. Hitesh Solanki is a pioneer Professor and Head in Department of Environmental Science and Botany, Gujarat University, Ahmadabad, Gujarat, India. He did his Ph.D. in Botany from Bhavnagar University. He guided 25

Ph.D. and 24 M.Phil candidates under his Guidance. Besides, He also guided more than 150 MSc. students. He has a Life Memberships of many organizations like The Indian Science Congress Association, The Indian Society of Remote Sensing: Space Application Center, Ahmadabad, Gujarat Ecological Education and Research Foundation. International Society for Research on Civilization Diseases and Environment. Indian Science News Association, Indian Association for Air Pollution Control, and The Plant Physiology Club, Bapatla (APAU).He also closely associated with ISRO and completed 3 major and 1 minor projects from ISRO. He also received many awards and recognition from different National and International organizations. He published more than 150 research papers, 12 books and many book chapters nationally and internationally.

Dr. Anil Kumar has completed UG, PG & Ph.D. from G.B.P.U.A. &T., Pantnagar, Uttarakhand. Working as an Assistant Professor-cum Junior Scientist in the Department of Plant Breeding & Genetics BAU, Sabour, Bhagalpur, India. Having twelve years of research experience in Cowpea, Finger millets, Oats, Rice and Lentil, Chickpea, Pigeonpea, Fababean and seven years of teaching UG, PG courses. Established Molecular Biology laboratory in the department with the financial support of SERB-DST, Harvest Plus, and CGIAR funded projects. Handled several university/state funded project on pulses. Guided three PG students as Major guide and Five as Co-guide. Published more than 50 research papers and presented more than 12 research papers in National & International conferences, more than 50 articles in hindi and english, eight book chapters, three authored books, four edited books and several extension materials Three varieties of pulses like Pant Lobia 3, Sabour Chana 1 and Sabour Chana 2 to in his credit . Organized several conferences nationally and internationally in association with several professional societies. Visited Beirut, Lebanon, Thailand, Bangkok for scientific interaction and trained at LARI, Beirut, Lebanon for pulses improvement. Active member of several committee of the university. Life member of several academic and professional Societies of India like ISGPB, ISPRD, SERS, Astha Foundation, SVWS and Fellow of SSDAT. Several awards conferred Young scientist award, Excellence in Teaching Award and

Excellence in Research Award Innovative Scientist award young Plant Breeder Award Distinguished Scientist awards etc.

Mr. Bilal Ahmad Rather has completed his MSc Botany from Osmania University, Hyderabad. He joined CSIR-CCMB, Hyderabad as JRF in the year 2017 and joined PhD in Department of Botany, Aligarh Muslim University, UP. He was also awarded CSIR-NET, JKSET, GATE, CSIR-JRF, ARS-NET, and TSSET. He has published many papers in top journals with high impact factor. He has attended various national and International Conferences. He has also been awarded as Young Professional Award by Green Agri Professional Society and Young Researcher awarded from United Lightning Vision.

Dr. Mohd Iqbal Rather is currently ICSSR Post Doc Fellow at Department of Agricultural Economics and Business Management Aligarh Muslim University. He has completed M.Phil and Ph.D from Aligarh Muslim University. He has edited six books on different themes of Economics and environmental Economics. He has authored a book on Higher Education also. He has been awarded Young Achiever Award by INSC Bangalore. He was also awarded UGC NET JRF and JKSET. He has attended various national and international conferences and also authored many research papers in various journals of national and international repute. He has also completed six months online course from Messtechetus Institute of Technology USA. He has also been awarded by Young Researcher Award by Green Agri Society. He is also editor and owner of Journal of Quantum Economics.

Dr. Akhtar Rasool is focusing on scientific development and the Scientific Innovations with recent research practices over cross. He apparently studied everything including environmental sciences medicine, science, natural philosophy, applied science, taxonomy etc. He hopes to make his outcome in to space one day. He also received many awards and recognition from different National and International organizations. He is Managing Director of United Lightning Vision and Science Letters Journal.

Mr. Mohammad Imran Mir is PhD student in the Department of Botany, Osmania University, Hyderabad. He has published many research articles. He has qualified ARS-NET. He has attended various national and international conferences.

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1. INTRODUCTION

Climate encompasses temperature, humidity, atmospheric pressure, wind, rainfall, atmospheric particle count and other meteorological elements in a given region over long periods of time. The Earth's climate is changing. 2001-2010 was the warmest decade on record since 1880 and the decade 1991-2000 was the second warmest (United Nations 2011). From 1906 to 2005, temperature has increased, on average, 0.74 °C per year. Correlated with this warming we have seen sea level rise, decreases in snow and ice cover and increased incidence of extreme weather events (IPCC 2007, 2007b, Anthohoff et al. 1999). The Stern Review on the Economics of Climate Change reports that by 2050, 200 million people may have been permanently displaced due to rising sea levels, increased floods and drought (Stern 2006). It is estimated that, since the 1970s, climate change has been responsible for over 150,000 deaths each year (McMichael et al. 2004).

At 1 °C increase in global temperature could easily double this figure (Patz et al. 2005). The principal drivers of climate change are variations in atmospheric concentrations of greenhouse gasses (GHG, including water vapour, carbon dioxide, methane, nitrous oxide, and ozone) and aerosols, as well as changes in land cover and solar radiation, all of which alter the energy balance of the Earth's climate. Terrestrial and marine ecosystems currently sequester carbon, acting as 'sinks'. Changes to atmospheric CO2 concentrations could shift the global carbon cycle towards annual net emissions, turning these ecosystems into 'sources'. Concentrations of other greenhouse gasses, including CH4 and N2O, which have similar effects, have also increased markedly as a result of human activities. The Continued GHG emissions at or above current levels will cause further warming and induce global climate change during the 21st century, very probably greater than that observed during the 20th century (IPCC 2007).

The basic mechanisms of the atmospheric 'greenhouse effect' are: sunlight passes through the atmosphere and heats the Earth's surface; the heated surface then cools by emitting infrared radiation into the atmosphere; most of this radiation is absorbed by greenhouse gases in the atmosphere, some of which is re-radiated back towards the ground and some into space.

The overall effect is to reduce the rate at which the Earth loses heat to space, making the surface and lower atmosphere warmer than they would otherwise be. IPCC (2007) predicts the average global temperatures are likely to rise between 1.1 and 6.4 °C (best estimates of 1.8 to 4 °C) above 1990 levels by the end of the 21st century, depending on our future greenhouse gas emissions. Projected changes in the temporal and spatial distribution of precipitation will see current local pattern sex acerbated. Such changes would have profound negative impacts on biodiversity and associated ecosystem services, some of which are outlined in Chapter 7. Assessment Report (AR) 4 from the Intergovernmental Panel on Climate Change (IPCC) describes key risks, including (IPCC 2007): A rise of 3 °C or more will result in significant loss of forest towards the end of the century, with serious implications for associated biodiversity (Jackson et al. 2008, Wardle 2008). Higher temperatures are likely to result in changes to the plankton communities upon which whole inland aquatic ecosystems depend. These changes will impact on the many people who derive their livelihoods from such environments.

History

The United Nations Framework Convention on Climate Change (UNFCCC) sets a context for intergovernmental efforts to tackle climate change and recognizes the Earth's climate system as a shared resource. The Kyoto Protocol, part of the UNFCCC, sets binding targets for 37 industrialized nations and the European Community for reducing their GHG emissions (UNFCCC 2011). This agreement will be extended until at least 2017. To replace it, 194 countries at the UN Climate Change Conference in Durban, November 2011, agreed to develop a legally binding mechanism by 2015, to come into force in 2020.

Emissions in 2008 were 38% higher than those in 1990; a total of 30.1 billion tonnes of CO2 have been emitted since this baseline year (United Nations 2011). An increase above 2-3 °C is very likely to trigger substantial changes in the structure of ecosystems and their ability to function (IPCC 2007). However, the emission reduction pledges made by participant countries at the Conference of the Parties in Cancun during 2010 would still result in a global temperature increase, by 2100, of at least 3.9 °C (Climate Interactive

2011). Even with successfully implemented climate change mitigation policies, significant change is inevitable due to lagged responses in the Earth's climate system (Oladosu et al. 2007). The IPCC is currently compiling AR5 which will place greater emphasis on the socio-economic aspects of climate change and implications for sustainable development.

Climate change is an issue that must be simultaneously tackled at all scales, by all parts of society. It is likely, for example, to challenge the realization of sustainable development, including the Millennium Development Goals, by reducing the livelihood assets of vulnerable people and by impacting on natural resources.

2. CORRELATION BETWEEN CLIMATE CHANGE AND BIODIVERSITY

The issues of climate change and biodiversity are interconnected, not only through climate change effects on biodiversity, but also through changes in biodiversity that affect climate change. Conserving natural terrestrial, freshwater and marine ecosystems and restoring degraded ecosystems (including their genetic and species diversity) is essential for the overall goals of the UNFCCC because ecosystems play a key role in the global carbon cycle and in adapting to climate change, while also providing a wide range of ecosystem services that are essential for human well-being and the achievement of the Millennium Development Goals. About 2,500 Gt C is stored in terrestrial ecosystems, an additional ~ 38,000 Gt C is stored in the oceans (37,000 Gt in deep oceans i.e. layers that will only feedback to atmospheric processes over very long time scales and ~ 1,000 Gt in the upper layer of oceans2) compared to approximately 750 Gt C in the atmosphere. On average ~160 Gt C cycle naturally between the biosphere (in both ocean and terrestrial ecosystems) and atmosphere. Thus small changes in ocean and terrestrial sources and sinks can have large implications for atmospheric CO_2 levels. Human induced climate change caused by the accumulation of anthropogenic emissions in the atmosphere (primarily from fossil fuels and land use changes) could shift the net natural carbon cycle towards annual net emissions from terrestrial sinks, and weaken ocean sinks through temperature rises and CO_2 concentrations, thus further accelerating climate change. Ecosystems provide a wide range of provisioning (e.g. food and fibre), regulating (e.g. climate change and floods), cultural (e.g. flagship species and aesthetic tourism) and supporting (e.g. soil formation) services, critical to human well-being including human health, livelihoods, nutritious food, security and social cohesion.

While ecosystems are generally more carbon dense and biologically more diverse in their natural state, the degradation of many ecosystems is significantly reducing their carbon storage and sequestration capacity, leading to increases in emissions of greenhouse gases and loss of biodiversity at the genetic, species and ecosystem level; Climate change is a rapidly increasing stress on ecosystems and can exacerbate the effects of other stresses, including from habitat fragmentation, loss and conversion, over-exploitation, invasive alien species, and pollution.

Field study conducted in Panama concluded that biodiversity ecosystems are likely to show greater resilience to a drying climate as the presence of several drought tolerant species provides ‘biological insurance’ to counter the loss of other species (Bunker et al., 2005).

Study conducted to investigate the effects of local bush meat hunting on the regeneration of tropical’s in the Ngotto Forest, Central African Republic. Assessed the deficit of plant recruitment due to large mammal extirpation because of hunting but concluded that more research is needed to better understand the effects of the disappearance of large seeded plants on tropical forest resilience (Vanthomme, 2010, Jackson et al. 2008, Ostrom et al. 2006).

Using archival photography and satellite imagery, many scientists analyzed the rates of advance or retreat of 103 coastal glaciers on South Georgia from the 1950s to the present. Ninety-seven percent of these glaciers have retreated over the period for which observations are available. The average rate of retreat has increased from 8 Ma-1 in the 1950s to 35 Ma-1 at present. The largest retreats have all taken place along the north-east coast, where retreat rates have increased to an average of 60 Ma-1 at present, but those on the south-west coast have also been steadily retreating since the 1950s. These data, along with environmental information about South Georgia, are included in a new Geographic Information System (GIS) of the island. By combining glacier change data with the present distribution of both endemic and invasive species we have identified areas where there is an increased risk of rat invasion to unoccupied coastal regions that are currently protected by glacial barriers. This risk has significant implications for the surrounding ecosystem, in particular depletion in numbers of important breeding populations of ground-nesting birds on the island.”

Warming in the southern Californian current system is driving seabird declines. See: Bird Life International (2008) Seabird communities are declining in the southern Californian current system.

3. CLIMATE CHANGE IMPACT

Climate change hastens extinctions of reptiles and amphibians in Madagascar. “New research from the American Museum of Natural History provides the first detailed study showing that global warming forces species to move up tropical mountains as their habitats shift upward. Christopher Raxworthy, Associate Curator in the Department of Herpetology, predicts that at least three species of amphibians and reptiles found in Madagascar’s mountainous north could go extinct between 2050 and 2100 because of habitat loss associated with rising global temperatures. These species, currently moving upslope to compensate for habitat loss at lower and warmer altitudes, will eventually have no place to move to.” Using Adaptive Management to Reduce the Impact of Climate Change on Biodiversity.

Climate change impacts biodiversity in a myriad of ways. Some species may even flourish under climatic conditions which are more favorable as a result of climate change. However, the rate of warming predicted is greater than anything which has been experienced for millions of years. Consequently there is a strong possibility that many species will find the physiological stress associated with temperature and precipitation changes too great, making it impossible for them to adapt (Pimm 2009). Whilst some changes will occur indirectly, as the result of climatic impacts on key ecological processes, including the frequency and intensity of fire events, predator-prey interactions, water flow, and nutrient cycling. Anthropogenic stresses such as habitat loss and fragmentation, as well as the introduction of any invasive species which they may interact with, might exacerbate the impacts of climate change.

For biodiversity conservation to be effective in the long-term, it is critical that practices address new climatic conditions and that efforts to reduce non-climatic stresses continue. This will support species, and the ecological processes upon which they depend on in order to adapt. With this aim in mind, there are several aspects to be considered, including:-the protection and restoration of ecological and evolutionary connectivity reducing other stresses (feral populations, pollution, habitat loss etc.) increasing the size and number of protected areas managing the matrices between protected areas pro-actively protecting large, intact landscapes and seascapes (Heller and Zavaleta 2009; Mackey et al. 2010; Watson et al. 2010).

The impacts of climate change can vary at a regional and even local scale (Trivedi et al. 2008), so in identifying relevant adaptation strategies, detailed climate change predictions specific to areas of conservation importance, and the likely responses of species are needed. Several tools are now available to facilitate this process.

Tools to combat the climate change

Tools which can provide fine-scale predictions of climate change impacts include Climate Wizard from The Nature Conservancy. Details of this and others are given below. Predictions at a regional scale are available from the IPCC (Christensen et al., 2007) as well as World Climate.

In addition to fine-scale climate change predictions, it is important to have good information on the species and the ecological functions present in the area, to assess the vulnerability of its biodiversity (IPCC 2014, Smit et al. 2006). The IUCN is producing tools to guide vulnerability assessments of a range of species; helpful for identifying how they might be affected by climate change (see below).

Integrating climate change adaptation plans into more general conservation planning is still in its infancy, however a number of tools have been developed recently to support this process (Groves et al. 2010).
The tools typically follow the framework of identification of biological features targeted for conservation including species, ecological processes and ecosystems.

CAUSE OF CLIMATE CHANGE

Scientists attribute the global warming trend observed since the mid-20th century to the human expansion of the "greenhouse effect" warming that result when the atmosphere traps heat radiating from Earth toward space.
Certain gases in the atmosphere block heat from escaping. Long-lived gases that remain semi-permanently in the atmosphere and do not respond physically or chemically to changes in temperature are described as "forcing" climate change. Gases, such as water vapor, which respond physically or chemically to changes in temperature, are seen as "feedbacks." Gases that contribute to the greenhouse effect include:

- **Water vapor:** The most abundant greenhouse gas, but importantly, it acts as a feedback to the climate. Water vapor increases as the Earth's atmosphere warms, but so does the possibility of clouds and precipitation, making these some of the most important feedback mechanisms to the greenhouse effect.

- **Carbon dioxide (CO_2):** A minor but very important component of the atmosphere, carbon dioxide is released through natural processes such as respiration and volcano eruptions and through human activities such as deforestation, land use changes, and burning fossil fuels. Humans have increased atmospheric CO_2 concentration by more than a third since the Industrial Revolution began. This is the most important long-lived "forcing" of climate change.

- **Methane:** A hydrocarbon gas produced both through natural sources and human activities, including the decomposition of wastes in landfills, agriculture, and especially rice cultivation, as well as ruminant digestion and manure management associated with domestic livestock (Antle 2009). On a molecule-for-molecule basis, methane is a far more active greenhouse gas than carbon dioxide, but also one which is much less abundant in the atmosphere.

- **Nitrous oxide:** A powerful greenhouse gas produced by soil cultivation practices, especially the use of commercial and organic fertilizers, fossil fuel combustion, nitric acid production, and biomass burning.

- **Chlorofluorocarbons (CFCs):** Synthetic compounds entirely of industrial origin used in a number of applications, but now largely regulated in production and release to the atmosphere by international agreement for their ability to contribute to destruction of the ozone layer. They are also greenhouse gases.

Not enough greenhouse effect: The planet Mars has a very thin atmosphere, nearly all carbon dioxide. Because of the low atmospheric pressure, and with little to no methane or water vapor to reinforce the weak greenhouse effect, Mars has a largely frozen surface that shows no evidence of life (Figure 1, 2).

Figure 1, 2: Showing not much Green House Effect.

Too much greenhouse effect: The atmosphere of Venus, like Mars, is nearly all carbon dioxide. But Venus has about 154,000 times as much carbon dioxide in its atmosphere as Earth (and about 19,000 times as much as Mars does), producing a runaway greenhouse effect and a surface temperature hot enough to melt lead (Figure 3).

Figure 3: Showing too much Green House Effect

On Earth, human activities are changing the natural greenhouse. Over the last century the burning of fossil fuels like coal and oil has increased the concentration of atmospheric carbon dioxide (CO_2). This happens because the coal or oil burning process combines carbon with oxygen in the air to make CO_2. To a lesser extent, the clearing of land for agriculture, industry, and other human activities has increased concentrations of greenhouse gases.

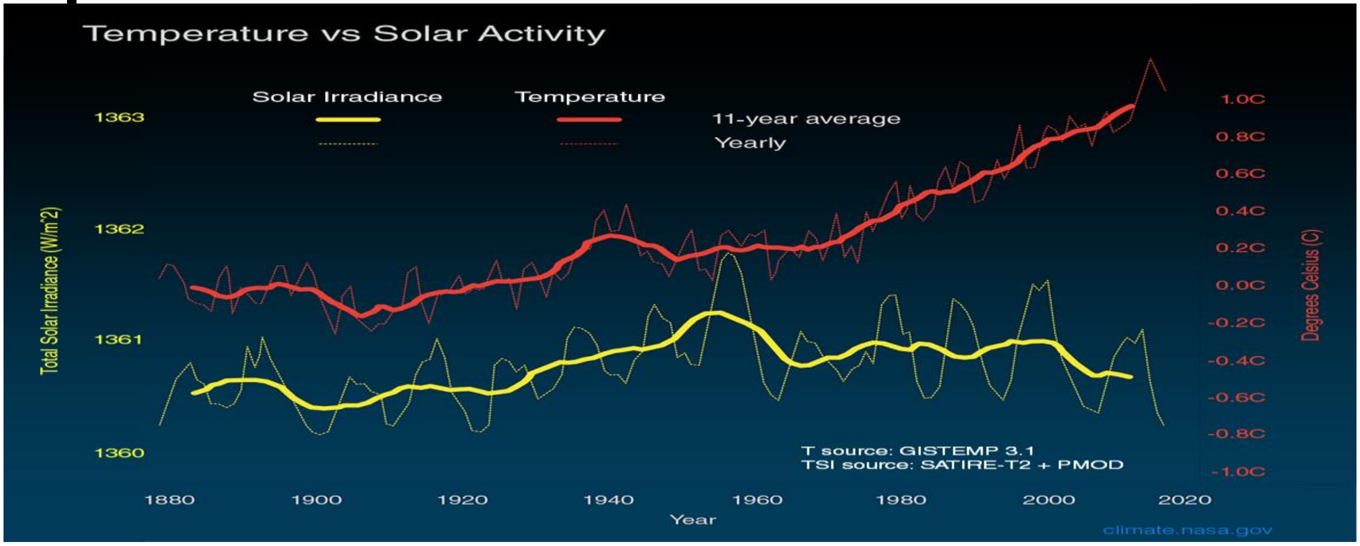


Figure 4: The above graph compares global surface temperature changes (red line) and the Sun's energy that Earth receives (yellow line) in watts (units of energy) per square meter since 1880.

The amount of solar energy that Earth receives has followed the Sun's natural 11-year cycle of small ups and downs with no net increase since the 1950s. Over the same period, global temperature has risen markedly. It is therefore extremely unlikely that the Sun has caused the observed global temperature warming trend over the past half-century. Credit: NASA/JPL-Caltech. It's reasonable to assume that changes in the Sun's energy output would cause the climate to change, since the Sun is the fundamental source of energy that drives our climate system.

Indeed, studies show that solar variability has played a role in past climate changes. For example, a decrease in solar activity coupled with an increase in volcanic activity is thought to have helped trigger the Little Ice Age between approximately 1650 and 1850, when Greenland cooled from 1410 to the 1720s and glaciers advanced in the Alps (Figure 4). But several lines of evidence show that current global warming cannot be explained by changes in energy from the Sun:

- Since 1750, the average amount of energy coming from the Sun either remained constant or increased slightly.

- If the warming were caused by a more active Sun, then scientists would expect to see warmer temperatures in all layers of the atmosphere. Instead, they have observed a cooling in the upper atmosphere, and a warming at the surface and in the lower parts of the atmosphere. That's because greenhouse gases are trapping heat in the lower atmosphere.

- Climate models that include solar irradiance changes can't reproduce the observed temperature trend over the past century or more without including a rise in greenhouse gases.

The consequences of changing the natural atmospheric greenhouse are difficult to predict, but certain effects seem likely:

- On average, Earth will become warmer. Some regions may welcome warmer temperatures, but others may not.

- Warmer conditions will probably lead to more evaporation and precipitation overall, but individual regions will vary, some becoming wetter and others dryer.

- A stronger greenhouse effect will warm the oceans and partially melt glaciers and other ice, increasing sea level (Bamber et al. 2009). Ocean water also will expand if it warms, contributing further to sea level rise.

- Meanwhile, some crops and other plants may respond favorably to increased atmospheric CO_2, growing more vigorously and using water more efficiently (Patz et al 2008). At the same time, higher temperatures and shifting climate patterns may change the areas where crops grow best and affect the makeup of natural plant communities.

5. IMPACT OF RISING SEA LEVEL

Global sea levels may rise by as much as 69cm during the next 100 years due to melting of glaciers and polar ice, and thermal expansion of warmer water.

Rising water levels will have serious impacts on ecosystems. The amount of light reaching offshore plants and algae dependent on photosynthesis could be reduced, while coastal habitats are already being flooded (Arrigo et al. 2008). Rapid sea level rise will likely be the greatest climate change challenge to mangrove ecosystems, which require stable sea levels for long-term survival. Global sea level has risen by about 8 inches since reliable record keeping began in 1880. It is projected to rise another 1 to 4 feet by 2100. This is the result of added water from melting land ice and the expansion of seawater as it warms.

In the next several decades, storm surges and high tides could combine with sea level rise and land subsidence to further increase flooding in many regions. Sea level rise will continue past 2100 because the oceans take a very long time to respond to warmer conditions at the Earth's surface. Ocean waters will therefore continue to warm and sea level will continue to rise for many centuries at rates equal to or higher than those of the current century. According to the IPCC, the extent of climate change effects on individual regions will vary over time and with the ability of different societal and environmental systems to mitigate or adapt to change.

The IPCC predicts that increases in global mean temperature of less than 1.8 to 5.4 degrees Fahrenheit (1 to 3 degrees Celsius) above 1990 levels will produce beneficial impacts in some regions and harmful ones in others. Net annual costs will increase over time as global temperatures increase.

Rising sea level

Climate change impacts rising sea levels. Average sea level around the world rose about 8 inches (20 cm) in the past 100 years; climate scientists expect it to rise more and more rapidly in the next 100 years as part of climate change impacts.

Coastal cities such as New York are already seeing an increased number of flooding events and by 2050 many such cities may require seawalls to survive (Adams 2009). Estimates vary, but conservatively sea levels are expected to rise 1 to 4 feet (30 to 100 cm), enough to flood many small Pacific island states (Vanatu), famous beach resorts (Hilton Head) and coastal cities (Bangkok, Boston).

If the Greenland ice cap and/or the Antarctic ice shelf collapses, sea levels could rise by as much as 20 ft (6 m), inundating, for example, large parts of Florida, the Gulf Coast, New Orleans and Houston.

Melting ice

Projections suggest climate change impacts within the next 100 years, if not sooner, the world's glaciers will have disappeared, as will the Polar ice cap, and the huge Antarctic ice shelf, Greenland may be green again, and snow will have become a rare phenomenon at what are now the world's most popular ski resorts.

While the specific conditions that produce rainfall will not change, climate change impacts the amount of water in the atmosphere and will increase producing violent downpours instead of steady showers when it does rain. Hurricanes and typhoons will increase in power, and flooding will become more common.

Anyone in the United States who has tried to buy storm and flood insurance in the past few years knows that the insurance industry is completely convinced that climate change is raising sea levels and increasing the number of major storms and floods.

Rising temperatures are hardly surprising, although they do not mean that some parts of the world will not “enjoy” record cold temperatures and terrible winter storms. (Heating disturbs the entire global weather system and can shift cold upper air currents as well as hot dry ones. Single snowballs and snowstorms do not make climate change refutations.) Increasingly, however, hot, dry places will get hotter and drier, and places that were once temperate and had regular rainfall will become much hotter and much drier. The string of record high temperature years and the record number of global droughts of the past decade will become the norm, not the surprise that they have seemed.

One of the most striking impacts of rising temperatures is felt in global agriculture, although these impacts are felt very differently in the largely temperate developed world and in the more tropical developing world. Different crops grow best at quite specific temperatures and when those temperatures change, their productivity changes significantly. In North America, for example, rising temperatures may reduce corn and wheat productivity in the US mid-west, but expand production and productivity north of the border in Canada. The productivity of rice, the staple food of more than one third of the world’s population, declines 10% with every 1^0 C increase in temperature. Past climate induced problems have been offset by major advances in rice technology and ever larger applications of fertilizer; expectations are that in Thailand, the world’s largest exporter of rice, however, future increases in temperatures may reduce production 25% by 2050.

At the same time, global population models suggest that developing world will add 3 billion people by 2050 and those developing world food producers must double staple food crop production by then simply to maintain current levels of food consumption.

Effect of vertical mixing

Vertical mixing in the ocean is important for many reasons, including transporting nutrients from deep to shallow waters, and surface water rich in oxygen into deeper waters. In some areas, changes to ocean temperature profiles induced by climate change are causing a reduction in the amount of mixing, and for example, reducing oxygen levels at depth.

Acidic nature on ocean life

After absorbing a large proportion of the carbon dioxide released by human activities, the oceans are becoming acidic. If it weren't for the oceans, the level of carbon dioxide in the atmosphere would be much higher.

The effect could be that fish, squid, and other gilled marine animals may find it harder to "breathe", as the dissolved oxygen essential for their life becomes difficult to extract as water becomes more acidic. And shellfish, crabs, lobsters, and corals may find it more difficult to build their calcium carbonate shells (Wilkinson 2000). In some areas, calcium carbonate shells may even start to dissolve.

6. THE ROLE OF HUMAN ACTIVITY

In its Fifth Assessment Report, the Intergovernmental Panel on Climate Change, a group of 1,300 independent scientific experts from countries all over the world under the auspices of the United Nations, concluded there's a more than 95 percent probability that human activities over the past 50 years have warmed our planet.

The industrial activities that our modern civilization depends upon have raised atmospheric carbon dioxide levels from 280 parts per million to 412 parts per million in the last 150 years. The panel also concluded there's a better than 95 percent probability that human-produced greenhouse gases such as carbon dioxide, methane and nitrous oxide have caused much of the observed increase in Earth's temperatures over the past 50 years.

The building of a conceptual model to illustrate the climatic, ecological, social/economic drivers affecting each feature; examine how the feature and its drivers may be affected by multiple plausible climate change scenarios; Identifying intervention points and potential actions to achieve objectives for each feature under each scenario; The identification and strengthening of key protected areas that are resilient to climate change; identifying bottlenecks; managing protected area networks to enhance landscape permeability for migratory, nomadic or wide-ranging species as well for the species with shifting ranges and to encourage a more environmentally sympathetic management of the landscape in general. assisted migration, captive breeding, and germplasm storage can all play a significant role in conservation activities. However, such measures are often expensive, less effective than in situ actions, only feasible on small scales and will rarely maintain vital ecosystem functions and services.

Incorporating climate change predictions and vulnerability assessments into national and local Protected Area policy and land-use management policies. Creating natural resource policies that address the interconnected impacts of climate change across separate ministries such as forestry, water, fisheries and wildlife. Incorporating adaptation into National Biodiversity Strategies and Action Plans (NBSAPs), to ensure that vulnerable ecosystems are addressed in National Adaptation Programmes of Action (NAPAs) and National Adaptation Plans (NAPs) and these plans are integrated into other policies (IPCC 2014; Wu et al. 2002).

7. IMPACT OF CLIMATE CHANGE ON CORAL REEFS

Ensuring that any impacts are understood in terms of ecosystem services losses so that they can be incorporated into National Poverty Reduction Strategies Coral Reef Conservation in the Face of Climate Change (NRC 2012).

Coral ecosystems are particularly vulnerable to climate change impacts. These rich marine ecosystems are important not just for biodiversity but also for the many people who depend upon them economically and socially (Basket et al. 2005). This article sets out a framework for identifying and investigating strategies for responding to climate change whilst minimizing risks to reefs and safeguarding local stakeholders' livelihoods using examples from the Western Indian Ocean. By considering both environmental susceptibility and social adaptive capacity, responses tailored to local conditions can be achieved (McClanahan et al. 2008).

Many Pioneer scientists have high confidence that global temperatures will continue to rise for decades to come, largely due to greenhouse gases produced by human activities. The Intergovernmental Panel on Climate Change (IPCC), which includes more than 1,300 scientists from the United States and other countries, forecasts a temperature rise of 2.5 to 10 degrees Fahrenheit over the next century.

8. OZONE DEPLETION AND CLIMATE CHANGE

Ozone depletion and climate change are linked in a number of ways, but ozone depletion is not a major cause of climate change (Battin et al. 2007). Atmospheric ozone has two effects on the temperature balance of the Earth. It absorbs solar ultraviolet radiation, which heats the stratosphere. It also absorbs infrared radiation emitted by the Earth's surface, effectively trapping heat in the troposphere. Therefore, the climate impact of changes in ozone concentrations varies with the altitude at which these ozone changes occur. The major ozone losses that have been observed in the lower stratosphere due to the human-produced chlorine- and bromine-containing gases have a cooling effect on the Earth's surface (Bell et al. 2006, Post et al. 2012) . On the other hand, the ozone increases that are estimated to have occurred in the troposphere because of surface-pollution gases have a warming effect on the Earth's surface, thereby contributing to the "greenhouse" effect.

In comparison to the effects of changes in other atmospheric gases, the effects of both of these ozone changes are difficult to calculate accurately. In the image below, the upper ranges of possible effects from the ozone changes are indicated by the open bars, and the lower ranges are indicated by the solid bars.

As shown in the figure, the increase in carbon dioxide is the major contributor to climate change. Carbon dioxide concentrations are increasing in the atmosphere primarily as the result of the burning of coal, oil, and natural gas for energy and transportation. The atmospheric abundance of carbon dioxide is currently about 30% above what it was 150 years ago. The relative impacts on climate of various other "greenhouse" gases are also shown on the figure.

There is an additional factor that indirectly links ozone depletion to climate change; namely, many of the same gases that are causing ozone depletion are also contributing to climate change. These gases, such as the chlorofluorocarbons (CFCs), are greenhouse gases, absorbing some of the infrared radiation emitted by the Earth's surface, thereby effectively heating the Earth's surface.

Conversely, changes in the climate of the Earth could affect the behavior of the ozone layer, because ozone is influenced by changes in the meteorological conditions and by changes in the atmospheric composition that could result from climate change. The major issue is that the stratosphere will most probably cool in response to climate change, therefore preserving over a longer time period the conditions that promote chlorine-caused ozone depletion in the lower stratosphere, particularly in polar regions. At present, the amplitude and extent of such a cooling, and therefore the delay in the recovery of the ozone layer, still have to be assessed.

9. ROLE OF CLIMATE CHANGE ON AGRICULTURE

In eastern India, farmers like Alex face growing challenges from climate change, including crop loss, soil erosion, and increased pests and plant diseases (CDC 2014). In 2018, the World Economic Forum ranked extreme weather events and natural s as the top two global risks for businesses in terms of likelihood. Modern supply chains rely on complex and increasingly interconnected global networks, leaving both companies and producers around the world (Cutter 2014). But climate change is a local issue just as much as it is a global issue.

In eastern India, farmers have recently been suffering decreased yields and lowered incomes because of higher temperatures and erratic rainfall. An increase in severe weather events, including extended droughts and periods of flooding, has led to extensive soil erosion and crop loss. With average temperatures in eastern Uganda expected to increase by 1.8 degrees Celsius, and average annual rainfall to increase by 15 percent by 2050, prioritizing climate resilience is essential for the long-term success of small-scale grain producers in the region.

Climate change and animal agriculture

Animal agriculture and fossil fuels are devastating our planet. We need to take drastic and immediate action. This year and decade are crucial if we are going to stop runaway climate chaos with areas of the world too hot to live in, with disease vectors spreading, ecological and agricultural systems breaking down and possibly leading to mass starvation, and more frequent and severe extreme weather events from hurricanes, floods, forest fires to droughts and sea level rise (Wu et al 2009).

Animal agriculture is a leading source of climate chaos, generating more greenhouse gas emissions (carbon dioxide, methane, nitrous oxide) than all cars, trucks, planes, ships and other transportation modes combined and responsible for critical land use changes: deforesting the world to produce animal feed.

According to the UN Environment Programme, the Earth is in the midst of a mass extinction of life. Scientists estimate that 150-200 species of plant, insect, bird and mammal become extinct every 24 hours. This is nearly 1,000 times the “natural” or “background” rate and, says many biologists, is greater than anything the world has experienced since the vanishing of the dinosaurs nearly 65m years ago.

Animal agriculture generates 51% or more of greenhouse gas emissions according to World Watch Institute. This figure includes all aspects of animal agriculture such as transportation of animals and related industries. The 14% Food and Agricultural Organization figure only includes limited aspects of animal agriculture such as raising animals for food.

10. EFFECT OF CLIMATE CHANGE ON MARINE BIODIVERSITY

The loss of marine biodiversity is weakening the ocean ecosystem and its ability to withstand disturbances, to adapt to climate change and to play its role as a global ecological and climate regulator.

The ocean is home to millions of species. The health of the oceans is strongly dependent upon this marine biodiversity (Sun et al. 2015). Life in the ocean is an essential component of climate regulation. Climate change due to human activity has a direct impact on marine species. It alters their abundance, diversity and distribution. Their feeding, development and breeding, as well as the relationships between species are affected.

- Rising temperatures lead to different behaviour patterns according to species. Some adapt to temperature changes, while others migrate toward the poles or to new areas. Other species disappear, as has been observed for certain corals that can rapidly bleach and die when their symbiosis with the unicellular algae, that they shelter and feed on, is interrupted.

- The ocean acidification, caused by an increasing absorption of atmospheric carbon dioxide (CO_2), has a direct impact on the marine organisms with calcareous skeletons or shells: these include phytoplankton, crustaceans, mollusks.

- Extreme climatic events deplete natural environments, for example by erosion and flooding. They disturb marine life in coastal areas, particularly in certain coastal habitats such as mangroves and seagrass beds, which are vital breeding grounds as well as potential CO_2 capture zones.

Fish is a primary source of animal protein for at least one billion people in the world. Apart from overfishing or pollution, climate change alone heavily affects the food resources for human populations, in developing countries essentially. Losses in biodiversity also imply a loss of genes and molecules that are potentially valuable for medical research and industry.

Due to these multiple changes that cumulate on marine ecosystems, the ocean is becoming, in turn, very sensitive to climate change. Indeed, the more ocean ecosystems become depleted, the less they are able to adapt to climate change. The severity of this situation has been considered too lightly.

11. STATUS OF CLIMATE CHANGE ON MARINE ECOSYSTEM AND MARINE ANIMALS

Marine species affected by climate change include plankton - which forms the basis of marine food chains - corals, fish, polar bears, walruses, seals, sea lions, penguins, and seabirds.

The Intergovernmental Panel on Climate Change predicts a further rise of between 1.4°C and 5.8°C by the end of the century (Aairme 2003). Climate change could therefore well be the knock-out punch for many species which are already under stress from overfishing and habitat loss. The key impacts of climate change on the marine environment are as follows:

- **Coral bleaching**

One of the most visually dramatic effects of climate change is coral bleaching, a stress response caused by high water temperatures that can lead to coral death. Recent years have seen widespread and severe coral bleaching episodes around the world, with coral mortality reaching 70% in some regions (Lewis et al. 2004).

Marine life faces challenges from warming waters and ocean acidification. Warming waters alter the latitude and depth at which certain species are able to survive, so many species are moving deeper or father north in the Atlantic to find cold water. More acidic oceans keep crustaceans, coral, and other organisms from developing. The result is widespread disruption of interconnected food webs.

Coral reefs threatened by climate change

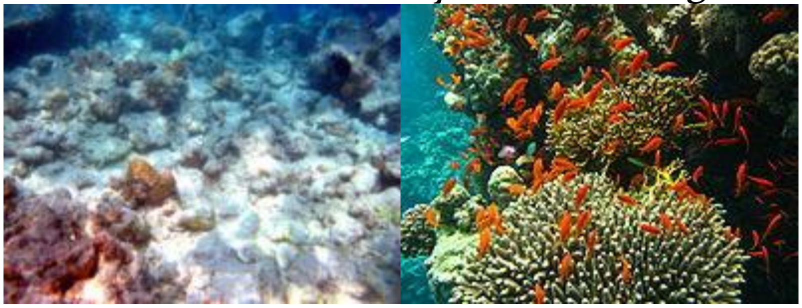
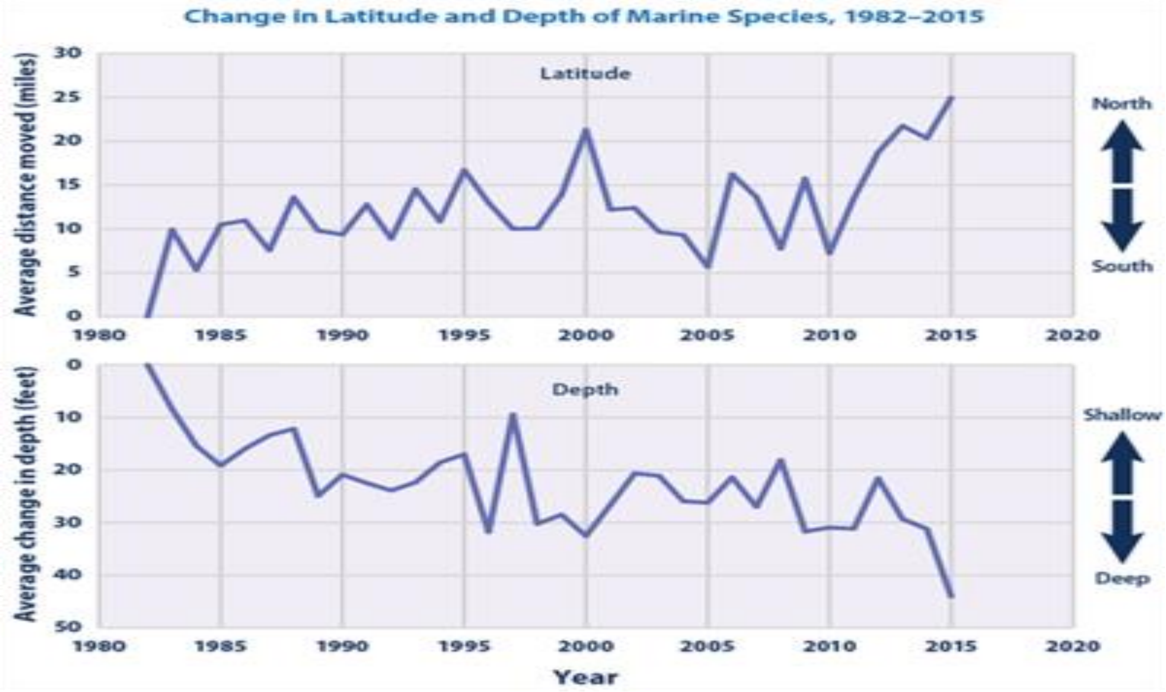


Figure 4: Coral bleaching results in white, dead-looking, coral.

Around the world, coral reefs have been dying largely due to climate change. Healthy coral is very colorful and rich with marine life. Coral reefs provide many ecosystem services to humans as well, for free (Figure 4). This site's page on coral reefs goes into these issues in more depth.

Moving northward & deeper marine animal

Overall, marine species are responding to warmer temperatures by moving northward or deeper when possible in search of cooler waters. On average, for 105 northern species in water off the northeastern U.S. and in the Bering Sea have shifted northward by about 10 miles between since 1982. They have also moved an average of 20 feet deeper (Figure 5). Since the late 1960s, three economically important species, American lobster, red hake, and black sea bass, have shifted northward 119 miles, on average.



Change in Latitude and Depth of Marine Species, 1982–2015

Figure 5: The graphs above show the average shift northward and toward deeper waters of 105 marine species along the Northeast coast and in the eastern Bering Sea.

Wellfleet Bay Wildlife Sanctuary has been tracking the number of cold-stunned sea turtles on Cape Cod since 1979, helping understand juvenile sea turtle population changes and behavior over several decades. Much is still unclear about sea turtle behavior, but cold-stun stranding numbers are increasing rapidly. This increase is likely due to a combination of successful conservation efforts on the nesting beaches in Mexico and Texas and changes in ocean temperatures, and possibly currents, driven by climate change.

Warmer sea surface temperatures are forcing lobster populations northward, disrupting ecosystems and the coastal economies that depend on them. The lobster industry in southern New England has virtually collapsed. Since 1996, New York's registered lobster landings dropped more than 98%. Connecticut is seeing the same, with a drop of about 97%, while Rhode Island a decline of more than 70%.

That doesn't mean the lobster populations have dropped overall. They are, in fact, remaining relatively stable, in part due to forward-thinking management practices, but they are being found farther north. While southern New England is losing lobsters, Maine is reaping the benefits with a 219% increase in registered lobster landings since 1994.

The challenge ahead is that lobster populations will not settle into place—they will keep moving northward until they run out of suitable habitat.
Historically, Cape Cod marked the northern extent of blue crabs' range. They were found south of the Cape, but not north. In recent years, that has change with warming waters and an enhanced gulf stream.

It's unlikely that blue crabs will be able to reliably breed in cooler waters north of the Cape. They may, however, increase in population off of New York, and during warm years, gain a temporary foothold in the Gulf of Maine. It will take decades to understand the pace at which climate change is affecting their range.

As our oceans warm, rising seas, stronger storms, and erosion will continue to impact many of our coastal breeding birds. In many cases, salt marshes will be unable to expand inland to offset losses to sea level rise, and salt marsh specialists like saltmarsh sparrows, seaside sparrows, willets, and clapper rails will lose precious habitat. Rising temperatures can directly affect the metabolism, life cycle, and behaviour of marine species. For many species, temperature serves as a cue for reproduction. Clearly, changes in sea temperature could affect their successful breeding.

The number of male and female offspring is determined by temperature for marine turtles, as well as some fish and copepods (tiny shrimp-like animals on which many other marine animals feed). Changing climate could therefore skew sex ratios and threaten population survival.
High-intensity storms will continue to degrade and destroy beach-nesting habitat for species like piping plover, roseate tern, and American oystercatcher.

Marine life & ocean acidification

Ocean acidification is impacting marine ecosystems in a number of ways. The thin shells of some pteropods, for example, can be completely dissolved within a month at the levels of acidity found off the New England coast. And there is a detrimental side effect.

In creating carbonic acid, free hydrogen ions are created. Those hydrogen ions react with carbonates to create additional carbonic acid, but those carbonates are needed by organisms to grow shells. The process of ocean acidification steals the molecules needed for organisms to thrive, in addition to corroding their shells and making the waters otherwise inhospitable. It’s a double whammy.

The coral, pteropods, shellfish, and crustaceans threatened by ocean acidification also serve as food sources for many other types of marine life and seabirds. As some species feel the direct effects and struggle, other food webs begin to collapse as well.

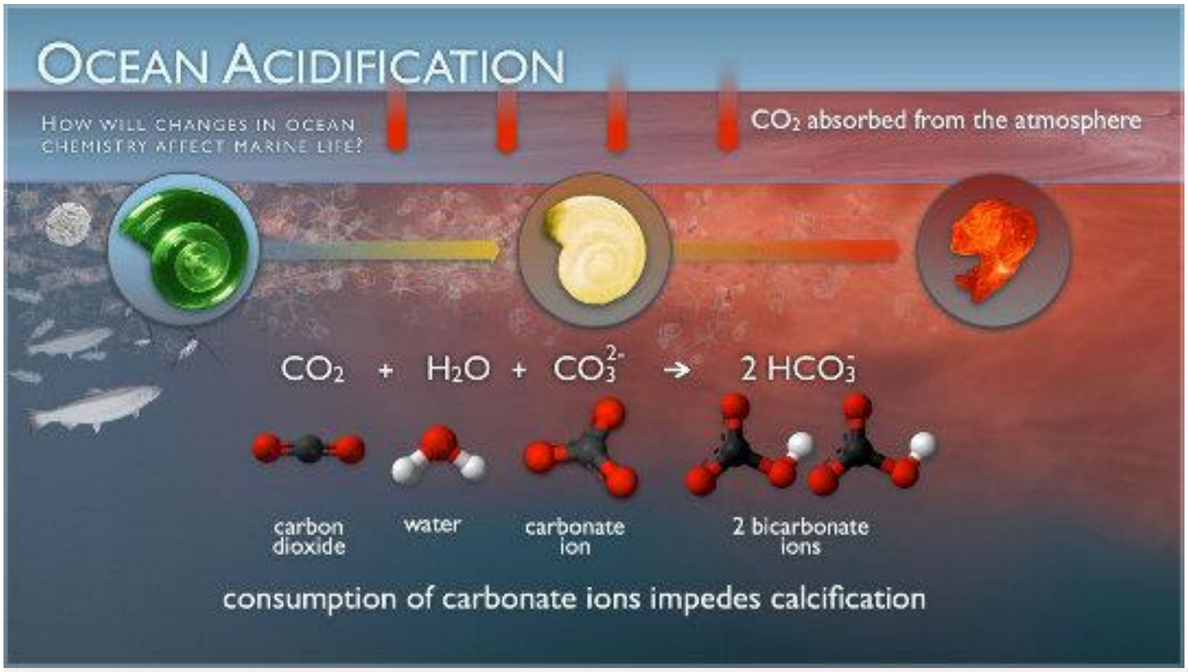

OCEAN ACIDIFICATION
HOW WILL CHANGES IN OCEAN CHEMISTRY AFFECT MARINE LIFE?
CO₂ absorbed from the atmosphere
CO₂ + H₂O + CO₃²⁻ → 2 HCO₃⁻
carbon dioxide
water
carbonate ion
2 bicarbonate ions
consumption of carbonate ions impedes calcification

Figure 6: Ocean Acidification, consumption of carbonate ions impede calcification

Scientists have found that oceans are able to absorb some of the excess CO_2 released by human activity. This has helped keep the planet cooler than it otherwise could have been had these gases remained in the atmosphere. However, the additional *excess* CO_2 being absorbed is also resulting in the acidification of the oceans: When CO_2 reacts with water it produces a weak acid called carbonic acid, changing the sea water chemistry. As the Global Biodiversity Outlook report explains, the water is some 30% more acidic than pre-industrial times, depleting carbonate ions — the building blocks for many marine organisms.

In addition, concentrations of carbonate ions are now lower than at any time during the last 800,000 years (Figure 6). The impacts on ocean biological diversity and ecosystem functioning will likely be severe, though the precise timing and distribution of these impacts are uncertain.

Although millions of years ago CO_2 levels were higher, today's change is occurring *rapidly*, giving many marine organisms too little time to adapt. Some marine creatures are growing thinner shells or skeletons, for example. Some of these creatures play a crucial role in the food chain, and in ecosystem biodiversity. Some species may benefit from the extra carbon dioxide, and a few years ago scientists and organizations, such as the European Project on Ocean Acidification, formed to try to understand and assess the impacts further.

One example of recent findings is a tiny sand grain-sized plankton responsible for the sequestration of 25–50% of the carbon the oceans absorb is affected by increasing ocean acidification (Akbari 2009). This tiny plankton plays a major role in keeping atmospheric carbon dioxide (CO_2) concentrations at much lower levels than they would be otherwise so large effects on them could be quite serious.

Increasing oceanic stratification

As climate change warms the oceans (even just an increase of about 0.2C per decade, on average), the warmer water (which is lighter) tends to stay on top of what is then a layer of colder water.

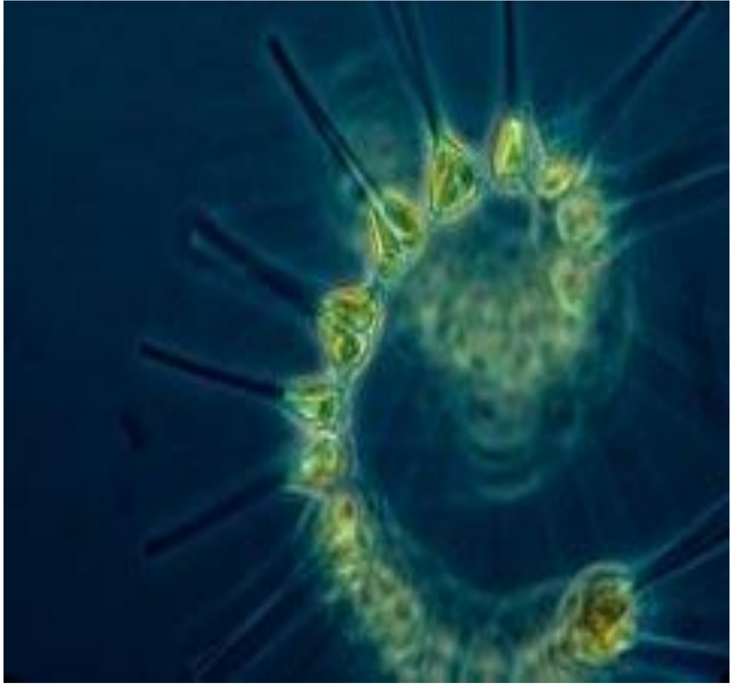


Figure 7: Tiny phytoplankton: the foundation of the oceanic food chain.

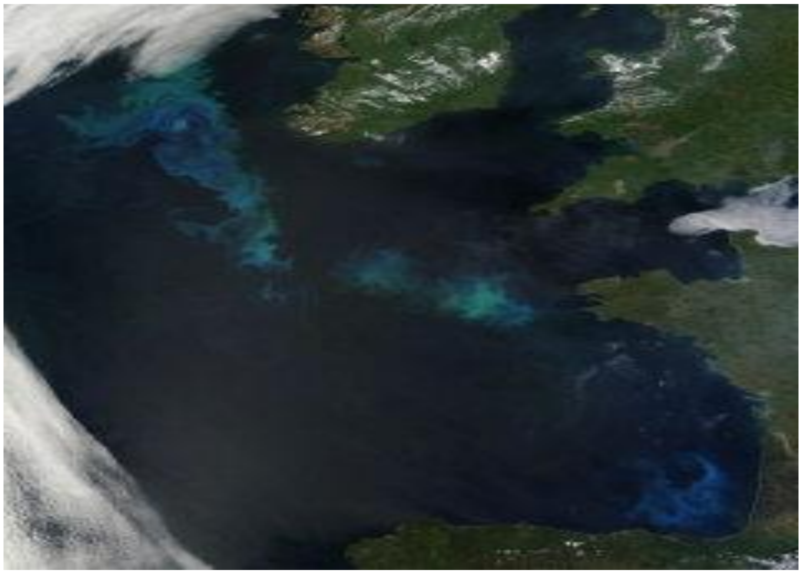


Figure 8: Phytoplankton Bloom in the North Atlantic.

This affects tiny drifting marine organisms known as phytoplankton. Though small, Phytoplankton are a critical part of our planetary life support system. They produce half of the oxygen we breathe, draw down surface CO2, and ultimately support all of our fisheries (Bayley 1981).

In the same news report, *IPS* explains that phytoplankton can only live in the top 100 or 200 meters of water, but if it is getting warmer, they eventually run out of nutrients to feed on unless the cold, deeper waters mix with those near the surface (Figure 7 & 8).

Researchers have found a direct correlation between rising sea surface temperatures and the decline in phytoplankton growth around the world.

Increasing oceanic dead zones

The past half-century has seen an explosive growth in aquatic dead zones, areas too low in dissolved oxygen to support life. Fertilizer and sewage run-off cause huge growth of plankton (Figure 9). However, these then quickly die and are consumed by bacteria that deplete waters of oxygen. For example, the Gulf of Mexico has a 22,000 square kilometer dead zone every spring due to run-off from the Mississippi River.

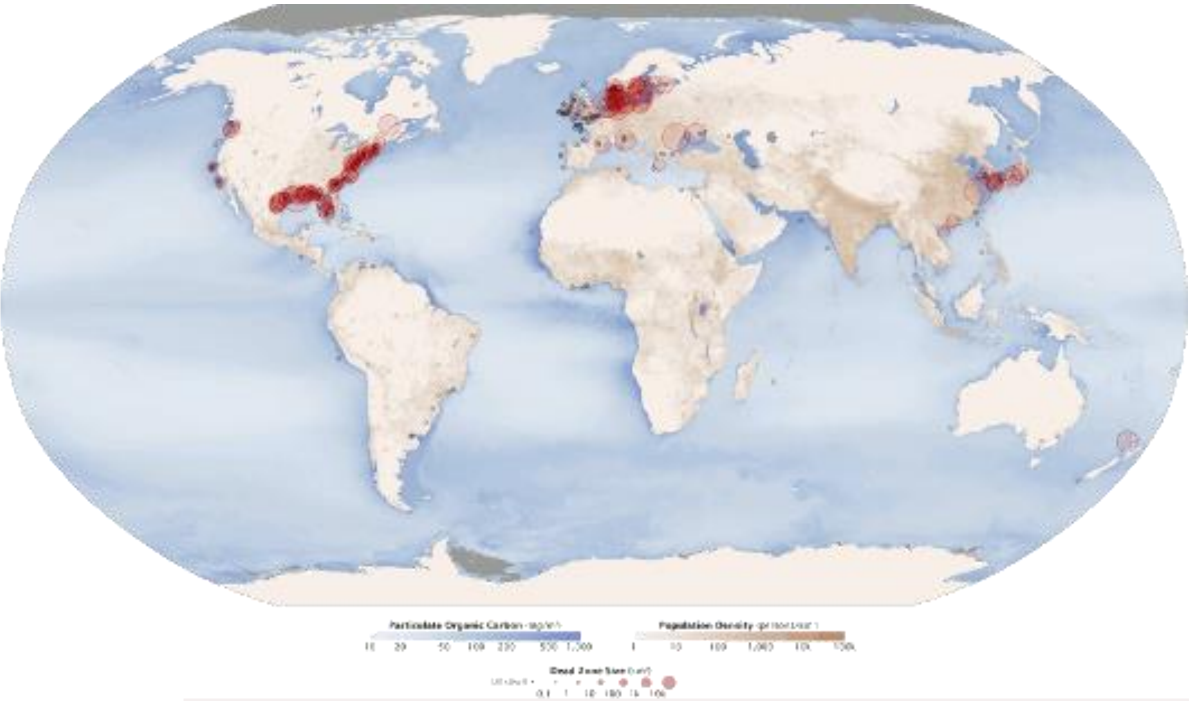


Figure 9: Aquatic dead zones often occur near high human population density.

12. LIZARDS THREATEND BY CLIMATE CHANGE

Global projection models used by the scientists suggested that lizards have already crossed a threshold for extinctions caused by climate change (Figure 10). The fear of lowland species moving to higher elevations has long been predicted as an effect of climate change. This has been observed with Lizards to be more susceptible to climate-warming extinction than previously thought. Many species live right at the edge of their thermal limits.

Figure 10: Impact of Climate change on Lizard

Rising temperatures, they explained, leave lizards unable to spend sufficient time foraging for food, as they have to rest and regulate their body temperature.

13. FOREST APPROACHES TO CLIMATE CHANGE MITIGATION USING REDD+

Forests cover around 30 percent of the Earth's land surface. . Because of ongoing deforestation, degradation and reforestation, estimates of forest cover are by no means static, nevertheless, it has been estimated that the amount of carbon currently stored in the earth's forests contain exceeds the amount of carbon in the entire atmosphere (Asner 2009, Paustian et al 2004). Internationally, In U.S., the length of the frost-free season (and the corresponding growing season) has been increasing nationally since the 1980s, with the largest increases occurring in the western United States, affecting ecosystems and agriculture (Becker 2010, Luers et al. 2004). Across the United States, the growing season is projected to continue to lengthen.
Some of the impacts that are currently visible throughout the U.S. and will continue to affect these regions are as follows:

- **Northeast.** Heat waves, heavy downpours and sea level rise pose growing challenges to many aspects of life in the Northeast. Infrastructure, agriculture, fisheries and ecosystems will be increasingly compromised. Many states and cities are beginning to incorporate climate change into their planning.

- **Northwest.** Changes in the timing of stream flow reduce water supplies for competing demands. Sea level rise, erosion, inundation, risks to infrastructure and increasing ocean acidity pose major threats. Increasing wildfire, insect outbreaks and tree diseases are causing widespread tree die-off.

- **Southeast.** Sea level rise poses widespread and continuing threats to the region's economy and environment. Extreme heat will affect health, energy, agriculture and more. Decreased water availability will have economic and environmental impacts.

- **Midwest.** Extreme heat, heavy downpours and flooding will affect infrastructure, health, agriculture, forestry, transportation, air and water quality, and more. Climate change will also exacerbate a range of risks to the Great Lakes.

- **Southwest.** Increased heat, drought and insect outbreaks, all linked to climate change, have increased wildfires. Declining water supplies, reduced agricultural yields, health impacts in cities due to heat, and flooding and erosion in coastal areas are additional concerns (Ebi et al.2008).

In a future in which heat-trapping gas emissions continue to grow, increases of a month or more in the lengths of the frost-free and growing seasons are projected across most of the U.S. by the end of the century, with slightly smaller increases in the northern Great Plains. The largest increases in the frost-free season (more than eight weeks) are projected for the western U.S., particularly in high elevation and coastal areas. The increases will be considerably smaller if heat-trapping gas emissions are reduced. Most of the planet's terrestrial carbon is in the above-ground biomass of forests, although, considerable amounts of carbon may be found in below ground biomass and in other carbon pools, such as, dead wood, litter and soil organic matter (Mellilo2014). From 1990-2005, it has been estimated that approximately 13 million hectares of forest were lost per year resulting in approximately 18% of global carbon dioxide (CO2) emissions. In fact, deforestation is the second largest source of emissions after the burning of fossil fuels and accounts for more than all the emissions from the transport sector. Further, in some countries, such as Brazil, Indonesia and many other tropical, developing countries, deforestation and forest degradation are the main source of national greenhouse gas emissions. Addressing emissions from forest loss is therefore a critical component of climate change mitigation.

Reducing Emissions from Deforestation and Forest Degradation (REDD) is a mechanism designed under the United Nations Framework Convention on Climate Change (UNFCCC) to reduce greenhouse gas (GHG) emissions from forested lands and invest in low-carbon paths to sustainable development, by offering incentives to tropical, forested countries to conserve and sustainably manage their forest resources. REDD incentives aim to make forests more valuable standing than they would be cut down, by creating a financial value for protecting the carbon stored in trees. "REDD-plus" (REDD+) goes beyond deforestation and forest degradation, to include the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in reducing emissions and enhancing removals of GHG from the atmosphere.

REDD+ was not included in the 1996 Kyoto Protocol; hence, incentives for avoided deforestation are not allowed under the Clean Development Mechanism.2 In 2007, at the 13th Conference of the Parties to the UN Framework Convention on Climate Change (COP-13) in Bali, parties acknowledged the importance of deforestation and forest degradation for climate change and agreed to work on the need to address emissions from forest loss. Although support for REDD+ has increased significantly since Bali, demonstrated by its inclusion in the Cancun agreement (COP16), there are still significant questions about how a future global REDD-plus mechanism will be designed.

One of the key questions remaining is at what scale(s) would REDD work effectively: at sub national or national levels. Proponents of the national approach note that REDD needs to be applied at a larger scale (national) in order to account for "leakage" or displacement of deforestation. Multilateral processes such as the World Bank Forest Carbon Partnership Facility and UN-REDD aim to help countries to develop national REDD+ strategies that map out how they might reduce emissions from land use change and develop systems for distributing benefits and monitoring change at this national scale.

Proponents of the sub-national approach (ex. projects or provinces) point to the fact that smaller scales are needed at this stage for testing methodologies, building capacity through "learning by doing", and attracting private sector capital. They highlight the potential of scaling up over time and possibly of creating an approach where projects are "nested" into a national accounting system.

Under both approaches, certain technical steps must be followed in order to calculate the climate benefit of REDD activities. These steps include: calculating the amount of carbon in the forest; estimating the historic rate of deforestation, projecting future deforestation based on a business as usual scenario (BAU, also known as Reference Emission Level (REL) and estimating future deforestation scenarios resulting from proposed REDD+ activities and/or other potential future changes likely to affect forest cover;, designing and implementing activities to reduce forest loss or enhance forest stocks; and monitoring and reporting loss over time. In addition, certain environmental and social safeguards must be designed and implemented, including consultation with relevant stakeholders (especially local communities and Indigenous peoples) and impact assessments.

Methodologies for each of these components have been or are being developed to guide project developers and national governments, although guidance is more prevalent for project-based REDD+ efforts than national ones. Most notably the Verified Carbon Standard (VCS) and the Climate Community and Biodiversity (CCB) standards both provide methodologies and guidance on how to measure project-level emission reductions and social and environmental impacts respectively. To be certified as a VCS or CCB approved project, the project must be validated by a third-party auditor. Certain key concepts are important to consider when developing REDD+_initiatives: 1) additionality; 2) permanence and 3) leakage. Additionality is required to demonstrate that the REDD+ initiative will reduce deforestation and forest degradation and/or enhance forest carbon stocks beyond what would have happened if the activities proposed were not implemented. Permanence refers to the assumption that projects or countries will reduce emissions for at least the period designated within the contract, and, thus, a tree protected today will not be cut down tomorrow. As noted above, leakage refers to the displacement of deforestation or forest degradation activities to another location, resulting in no net benefit of emissions reductions to the atmosphere. Projects and plans must demonstrate that leakage has been accounted for in project or policy design (Pohe 2008). Monitoring, Reporting and Verification (MRV) systems must be designed to track potential leakages and permanence of emissions reductions claimed by project developers.

Although these technical steps are important to demonstrate that emissions are real and verifiable, the most important and challenging aspect of REDD+ is designing activities that actually reduce deforestation and degradation in the long term. Financial incentives, while important, often need to be buttressed by other benefits, such as improved resource rights, welfare, and capacity building. Furthermore, the implementation of REDD+ at any scale requires good governance, which is often a challenge in many tropical, developing countries where much of the world's forests remain.

14. CLIMATE CHANGE PERFORMANCE INDEX

The Climate Change Performance Index (CCPI) presented today at the climate summit in Madrid reflects opposing trends in global climate action: Australia, Saudi Arabia and especially the USA give cause for great concern with their low to very low performance in emissions and renewable energy development as well as climate policy. With these three governments massively influenced by the coal and oil lobby, there are hardly any signs of serious climate policy in sight. On the other hand, global coal consumption is falling and the boom in renewable energy continues. In 31 of the 57 high emitting countries assessed, collectively responsible for 90 percent of emissions, falling emission trends are recorded.
Majority of Countries show decline in emissions and Climate change performance Index are as follows:

- Climate Change Performance Index 2020: Decreasing emissions in 31 out of 57 high emitting countries - global coal consumption falling
- But more ambition and accelerated action needed
- USA for the first time replaces Saudi Arabia as worst performing country
- Sweden continues to lead, Denmark climbs up significantly in the ranking

In some country, in Madrid, The Climate Change Performance Index (CCPI) presented today at the climate summit in Madrid reflects opposing trends in global climate action: Australia, Saudi Arabia and especially the USA give cause for great concern with their low to very low performance in emissions and renewable energy development as well as climate policy. With these three governments massively influenced by the coal and oil lobby, there are hardly any signs of serious climate policy in sight. On the other hand, global coal consumption is falling and the boom in renewable energy continues. In 31 of the 57 high emitting countries assessed, collectively responsible for 90 percent of emissions, falling emission trends are recorded.

"The new Climate Change Performance Index shows signs of a global turnaround in emissions, including declining coal consumption. However, several large countries are still trying to resist this trend - above all the USA. We see opportunities for a halt to rising global emissions - but much will depend on further developments in China and the elections in the USA.

Role of G 20 Countries in combating climate change

As none of the countries assessed is already on a path compatible with the Paris climate targets, the first three places of the ranking remain unoccupied. While some EU countries such as Sweden (4th) - again the frontrunner - and Denmark (5th), one of the best climbers, achieve overall high or very high ratings, the performance of EU countries varies largely: Eight EU countries are rated high, eight low and two very low. Bulgaria (49th) and Poland (50th) are the worst performing EU countries, both with a very low policy rating and Poland with low to very low results on renewable energy. The worst EU performer of last year, Ireland, has improved its position in the ranking by seven places (41st). The European Union as a whole ranks 22nd, Germany 23rd (both "medium"). "The EU has lost a few ranks but could move up again if it were to follow the recommendation by the new president of the European Commission to increase the emission reduction target from -40% to -55% by 2030 compared to 1990 and adopt a long-term strategy for reaching climate neutrality by 2050.

China, the largest global emitter, once again slightly improves its ranking to 30th place. China scores with a very good performance for its increased share of renewables in the energy mix over recent years and relatively good policy ratings, but the poor performance in emissions and energy efficiency still weighs heavily. If China implements its extensive plans for new coal-fired power plants, there is a risk of a severe relapse to the bottom of the ranking.

While only two G20 countries, the UK (7th) and India (9th), are ranked in the "high" category, eight G20 countries are remaining in the worst category of the index ("very low"). Australia (56th out of 61), Saudi Arabia and above all the USA perform particularly poor - the USA is the worst performer for the first time. Under the Trump administration, the USA is rated "low" or "very low" in almost all categories; in the category climate policy only Australia performed worse, which received 0 out of 100 possible points based on the assessment of climate experts in the country. "This science based assessment shows again that in particular the large climate polluters do hardly anything for the transformational shift we need to deep emissions reductions to curtail the run to potentially irreversible climate change. If necessary and strongly enhanced climate finance and loss and damage support by the wealthy nations for the poorer countries were to be included also the various higher ranking European countries would be performing much lower in the scores", Dr. Stephan Singer from the Climate Action Network (CAN), co-publisher of the CCPI, says.

The Climate Change Performance Index by German watch and New Climate Institute

The Climate Change Performance Index by German watch and New Climate Institute published together with the Climate Action Network (CAN) is a ranking of the 57 countries (new: Chile) and the EU, collectively responsible for about 90% of global GHG emissions. The four categories assessed are: GHG Emissions (40%), Renewable Energy (20%), Energy Use (20%) and Climate Policy (20%). The latter is based on expert assessments by NGOs and think tanks from the respective countries. Within the categories GHG Emissions, Renewable Energy and Energy Use the CCPI also evaluates to what extent the respective countries are taking adequate action to be on track towards the global Paris-goal of limiting global warming to well below 2°C. Therefore, the CCPI is an important tool to enhance transparency in international climate politics and enables comparison of climate protection efforts and progress made by individual countries.

15. POLICY AND RESPONSES OF CLIMATE CHANGE FOR FUTURE

One of the integral steps in including knowledge into decision-making is the formulation and understanding of the response options available to the range of actors carrying out decisions in different sectors and at different scales. These actors include national governments, intergovernmental organizations, domestic and international private operators, non-governmental organizations, and local communities. The different responses of these actors thereby represent differences in the scale and context in which they operate and many of them are interrelated whereby one response can feed into another. The intensity, frequency and duration of North Atlantic hurricanes, as well as the frequency of the strongest hurricanes, have all increased since the early 1980s. The relative contributions of human and natural causes to these increases are still uncertain (Alberechta 2009), Hurricane-associated storm intensity and rainfall rates are projected to increase as the climate continues to warm.

International policy responses - Global problems require global solutions. This is certainly the case for threats such as climate change which are global in nature, but is also true for many more localized threats related to biodiversity loss and ecosystem degradation as a result of globalised trade networks and the distribution of the world's wealth, resources and biodiversity. This need for an international response has given rise to a number of Multilateral Environmental Agreements (MEAs): agreements between Member states on issues related to the environment, often supported by the United Nations. Of significance is the Convention on Biological Diversity (CBD, see Chapter 2) and the United Nations Framework Convention on Climate Change.

National policy responses – Most countries have a number of policies and regulations that relate to the environment (AMS 2009). While these are often developed in response to threats perceived at the local or national level, they are also in response to MEAs to which they have committed. As an example, signatories to the CBD are required to develop National Biodiversity Strategy and Action Plans (NBSAPs) that feeds into national level instruments for regulation, land designation, procurement policies, education, funding and incentive schemes etc. Equally, signatories to the Kyoto protocol of the UNFCCC are committed to binding greenhouse gas emission reduction targets, which then direct national-level strategies, including regulatory mechanisms and engagement in market-based mechanisms for the trade of emission permits.

Private sector responses – Businesses are increasingly engaged at local, national and international scales, in response to the risks and opportunities associated with biodiversity and ecosystem services (see Chapter 3). The drivers behind this trend include consumer preferences for sustainably produced goods and services, stringent sustainability standards for accessing financial capital, reputational implications associated with biodiversity management practices, and liability resulting from adverse impacts on the environment. Companies are responding by developing biodiversity policies, implementing impact mitigation strategies, conforming to best practice guidelines and standards, providing conservation investment, and adopting market-based mechanisms such as payment for ecosystem services (PES) schemes and biodiversity and carbon offsetting (UNEP 2010). Such efforts are often supported through partnerships with international conservation NGOs, as well as through membership to industry associations (e.g. International Council for Mining and Metals (ICMM)) and business councils (e.g. World Business Council for Sustainable Development (WBCSD).

Local level responses – Many conservation interventions ultimately occur at the local level, whether in response to national or international policies through a ‘top down’ approach or whether through local community, local government or local NGO led ‘bottom up’ approaches. Local communities are increasingly recognised as stewards of their own environment, as there is increasing recognition of the field of Community Based Natural Resource Management (CBNRM). The effectiveness of CBNRM does, however, heavily depend on the local context in which it operates, in particular, governance capacities; resource conditions; and local customs (Brunkhorst 2010).

Types of responses that can be enacted have been broadly categorized by Simpson and Vira (2010) as:

- Community management – formal and recognized by national/local government, or informal traditional systems

- Command-and-control regulation – enactment of statutes or regulation by local and national governments, as well as internationally in the case of the legally binding Convention on the International Trade in Endangered Species (CITES)

- Market-based incentives tax- or fee-based systems, cap-and-trade approach, biodiversity and carbon offsets

- Payment for ecosystem services (PES) programs – offering incentives in exchange for the management of an area for the provision of ecosystem services.

- Sustainable use strategies – often through community management, and often supported by market-based certification schemes, and high level policies such as those of the CBD

Responses to ecosystem degradation are therefore varied in nature and scale, and identifying the appropriate intervention depends on the problem at hand. Comparing the effectiveness of different responses requires consideration of the scale at which the consequences of ecosystem change are felt, the capacity of actors to effect a change, and the awareness that the change is occurring.

The Millennium Ecosystem Assessment (MA) identifies five types of problem that might result in the degradation of ecosystems: Poor governance, market failures, social and behavioral factors, under-investment in ecosystem service based technology, and insufficient knowledge (Simpson and Vira 2010). The ability to tackle these problems depends on the instruments themselves: technologies, market mechanisms, regulations, subsidies, alternative harvest strategies etc.

Given the trade-offs between ecosystem services, whereby different beneficiaries often have different needs and competing interests, any response that tackles a specific problem will result in winners and losers. When considering different response options, a number of options are available to help balance competing interests: 1. Multi-criteria analysis, 2. Cost-benefit analysis, and 3. Cost-effectiveness analysis.

The global climate is the connected system of sun, earth and oceans, wind, rain and snow, forests, deserts and savannas, and everything people do, too. The climate of a place, say New York, can be described as its rainfall, changing temperatures during the year and so on. But the global climate is more than the "average" of the climates of specific place. A description of the global climate includes how, for example, the rising temperature of the Pacific feeds typhoons which blow harder, drop more rain and cause more damage, but also shifts global ocean currents that melt Antarctica ice which slowly makes sea level rise until New York will be under water. It is this systemic connectedness that makes global climate change so important and so complicated.

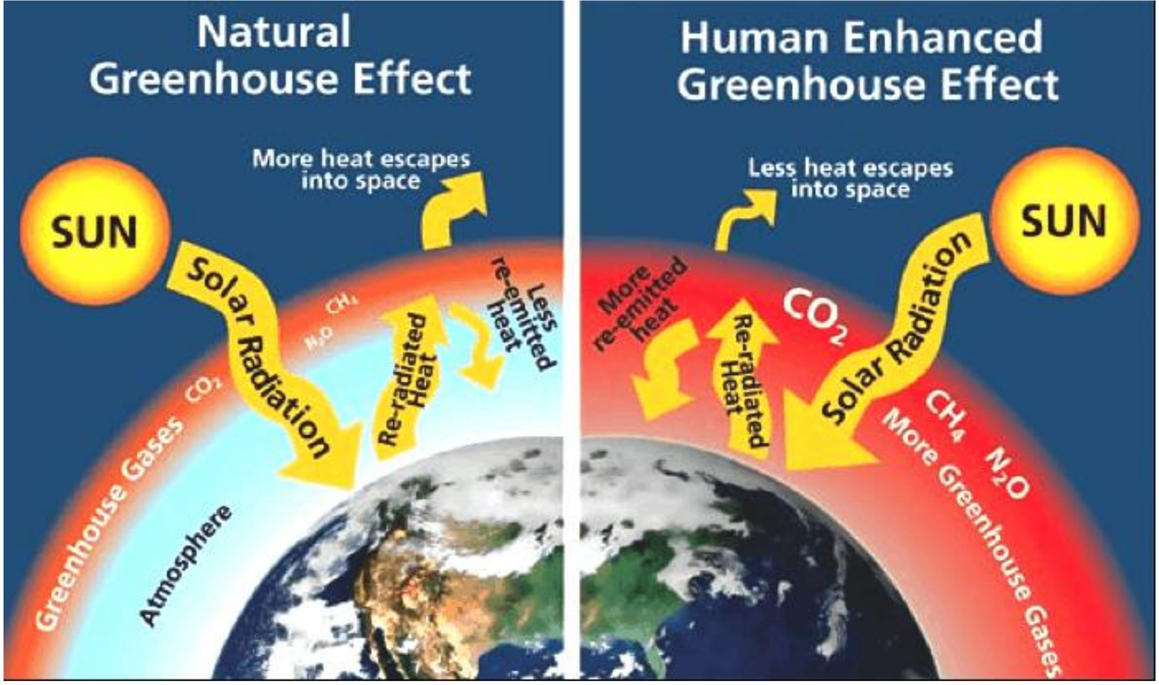


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Figure 11: Showing the effect between Natural Greenhouse Effect and Human enhanced Greenhouse Effect.

Without our atmospheric greenhouse the earth would be very cold. Global warming, however, is the equivalent of a greenhouse with high efficiency reflective glass installed the wrong way around (Figure 11).

Ironically, the best evidence of this may come from a terrible cooling event that took place some 1,500 years ago. Two massive volcanic eruptions, one year after another placed so much black dust into the upper atmosphere that little sunlight could penetrate. Temperatures plummeted. Crops failed.

People died of starvation and the Black Death started its march. As the dust slowly fell to earth, the sun was again able to warn the world and life returned to normal.

Today, we have the opposite problem. Today, the problem is not that too little sun warmth is reaching the earth, but that too much is being trapped in our atmosphere.

So much heat is being kept inside greenhouse earth that the temperature of the earth is going up faster than at any previous time in history. NASA provides an excellent course module on the science of global warming.

Because all systems in the global climate system are connected, adding heat energy causes the global climate as a whole to change. Much of the world is covered with ocean which heats up. When the ocean heats up, more water evaporates into clouds. Where storms like hurricanes and typhoons are forming, the result is more energy-intensive storms. A warmer atmosphere makes glaciers and mountain snow packs, the Polar ice cap, and the great ice shield jutting off of Antarctica melt raising sea levels (Lythe et al. 2001, Mathes et al. 1939).

Changes in temperature change the great patterns of wind that bring the monsoons in Asia and rain and snow around the world, making drought and unpredictable weather more common.

16. CORELATION OF GLOBAL WARMING AND CLIMATE CHANGE

Climate change refers to significant, long-term changes in the global warming. Climate change and Global warming are the correlated issues for global impact in nature. There are three positions on global warming: (1) that global warming is not occurring and so neither is climate change; (2) that global warming and climate change are occurring, but these are natural, cyclic events unrelated to human activity; and (3) that global warming is occurring as a result primarily of human activity and so climate change is also the result of human activity.

The claim that nothing is happening is very hard to defend in the face or masses of visual, land-based and satellite data that clearly shows rising average sea and land temperatures and shrinking ice masses.

The claim that the observed global warming is natural or at least not the result of human carbon emissions (see Climate Skeptics below) focuses on data that shows that world temperatures and atmospheric CO2 levels have been equally high or higher in the past. They also point to the well understood effects of solar activity on the amount of radiation striking the earth and the fact that in recent times the sun has been particularly active.
The massive cause of Climate change are:

- **Fossil Fuel**
  The massive use of fossil fuels is obviously the first source of climate change due to heat generation, as burning coal, oil and gas produces carbon dioxide - the most important greenhouse gas in the atmosphere - as well as nitrous oxide.

- **Deforestation**
  The exploitation of forests has a major role in climate change. Trees help regulate the climate by absorbing CO2 from the atmosphere. When they are cut down, this positive effect is lost and the carbon stored in the trees is released into the atmosphere.

- **Intensive Farming**
  Another cause of climate change is intensive farming, not only with the ever-increasing livestock, but also with plant protection products and fertilizers. In fact, cattle and sheep produce large amounts of methane when digesting their food, while fertilizers produce nitrous oxide emissions.

- **Waste Disposal**
  Waste management methods like landfills and incineration emit greenhouse and toxic gases - including methane - that are released into the atmosphere, soil and waterways, contributing to the increase of the greenhouse effect.

- **Mining**
  Modern life is highly dependent on the mining and metallurgical industry. Metals and minerals are the raw materials used in the construction, transportation and manufacturing of goods. From extraction to delivery, this market accounts for 5% of all greenhouse gas emissions.

- **Overconsumption**
  Finally, overconsumption also plays a major role in climate change. In fact, it is responsible for the overexploitation of natural resources and emissions from international freight transport, \

Role of Black Carbon to cause global warming

Black carbon (BC) is tiny particles of carbon released as a result of the incomplete combustion of fossil fuels, biofuels and biomass. These particles are extremely small, ranging from 10 µm (micrometers, PM10), the size of a single bacterium to less than 2.5 µm (PM2.5), one thirtieth the width of a human hair and small enough to pass through the walls of the human lung and into the bloodstream.

Although BC – think of the plume of smoke from a chimney or a fire – falls out of the lower atmosphere in days, while it is suspended in the air, it absorbs the sun's heat millions of times more effectively than CO_2. When wind carries BC over snow, glaciers or ice caps where it falls out onto the white, normally reflective surface, it is particularly damaging because it contributes directly to melting. Overall, BC is considered the second biggest contributor to global warming after CO_2.

In general, climate scientists and environmentalists either (1) dispute the data based on, for example, new ice core data or (2) suggest that the timing issue – that is, the rapidity with which the globe has warmed and the climate changed simply do not fit the model of previous natural events. They note also that compared to other stars the sun is actually very stable, varying in energy output by just 0.1% and over a relatively short cycle of 11 to 50 years quite unrelated to global warming as a whole. The data strongly suggests that solar activity affects the global climate in many important ways, but is not a factor in the systemic change over time that we call global warming.

As for the final position that global warming and climate change result from human activity (are "anthropogenic"), scientists attribute current atmospheric warming to human activities that have increased the amount of carbon containing gases in the upper atmosphere and to increased amounts of tiny particles in the lower atmosphere.

Specifically, gases released primarily by the burning of fossil fuels and the tiny particles produced by incomplete burning trap the sun's energy in the atmosphere. Scientists call these gases "greenhouse gases" (GHGs) because they act like the wrong way reflective glass in our global greenhouse.

Scientists call the tiny particles 'black carbon' (you call it soot or smoke) and attribute their warming effect to the fact that the resulting layer of black particles in the lower atmosphere absorbs heat like a black blanket (Wang 2007).

Scientists date the beginning of the current warming trend to the end of the 18th or beginning of the 19th century when coal first came into common use. This warming trend has accelerated as we have increased our use of fossil fuels to include gasoline, diesel, kerosene and natural gas, as well as the petrochemicals (plastics, pharmaceuticals, fertilizers) we now make from oil. Scientists attribute the current warming trend to the use of fossil fuels because using them releases into the atmosphere stores of carbon that were sequestered (buried) millions of years ago. The addition of this "old" carbon to the world's current stock of carbon, scientists have concluded, is what is heating our earth which causes global warming.

17. CAUSE OF CLIMATE CHANGE ON HUMAN HEALTH

Human health has always been influenced by climate and weather. Changes in climate and climate variability, particularly changes in weather extremes, affect the environment that provides us with clean air, food, water, shelter, and security (O Brien et al. 2009). Climate change, together with other natural and human-made health stressors, threatens human health and well-being in numerous ways. Some of these health impacts are already being experienced in the United States (Tamerius et al 2007).

Given that the impacts of climate change are projected to increase over the next century, certain existing health threats will intensify and new health threats may emerge. Connecting our understanding of how climate is changing with an understanding of how those changes may affect human health can inform decisions (Johnson 2014) about mitigating (reducing) the amount of future climate change, suggest priorities for protecting public health, and help identify research needs (NRC 1986).

In order to understand how climate change creates or exacerbates health problems, assessments of climate change health impacts must start with what is known about the current state and observed trends in a wide array of health conditions. In addition, because pre existing health conditions, socioeconomic status, and life stage all contribute to vulnerability to climate-related and weather-related health effects, assessments of climate change health impacts should be informed by projected changes in these factors. In cases where people's health or socioeconomic status is getting worse, climate change may accentuate the health burdens associated with those worsening trends. Conversely, in cases where people's health or socioeconomic status is improving, the effect of climate change may be to slow or reduce that improvement. Where the state of scientific understanding allows, the inclusion of projected trends in health and socioeconomic conditions into models of climate change impacts on health can provide useful insights into these interactions between non-climate factors and climate change effects.

Population growth and migration in the United States may place more people at risk of the health impacts of climate change, especially as more people are located in and around vulnerable areas, such as coastal, low-lying, or flood-prone zones; densely populated urban areas; and drought-stricken or wildfire-prone regions (Gallopin et al. 2006, U. S. 2010, 2015).

Increases in racial and ethnic diversity and in the number of persons living near the poverty line may increase the risk of health impacts from climate change. Economic disparity can make it difficult for some populations to respond to dangerous weather conditions, especially when evacuation is necessary or when the aftermath requires rebuilding of homes and businesses not covered by home or property insurance (Figure 12).

Figure 12: Home Damaged after Hurricane

As a nation, trends in the population's health are mixed. Some major indicators of health, such as life expectancy, are consistently improving, while others, such as rate and number of diabetes deaths, are getting worse (Figure 13). Changes in these metrics may differ across populations and over time. For example, though rates of obesity have increased in both children and adults over the last 30 years or more, rates over just the last decade have remained steady for adults but increased among children (Fryer 2012).

Climate change impacts to human health will act on top of these underlying trends. Some of these underlying health conditions can increase sensitivity to climate change effects such as heat waves and worsening air quality (Walsh 2014). Understanding the trends in these conditions is therefore important in considering how many people are likely to experience illness when exposed to these climate change effects. Potential climate change related health impacts may reduce the improvements that would otherwise be expected in some indicators of health status and accentuate trends towards poorer health in other health indicators.'

Examples of health indicators that have been improving between 2000 and 2013 include the following:

- Life expectancy at birth increased from 76.8 to 78.8 years.
- Death rates per 100,000 people from heart disease and cancer decreased from 257.6 to 169.8 and from 199.6 to 163.2, respectively.
- The percent of people over age 18 who say they smoke decreased from 23.2% to 17.8%.

Figure 13: Diabetes increases due to sensitivity Heat Stress.

At the same time, some health trends related to the prevalence of chronic diseases, self-reported ill health, and disease risk factors have been getting worse. For example:

- The percentage of adult (18 years and older) Americans describing their health as "poor or fair" increased from 8.9% in 2000 to 10.3% in 2012.

- Prevalence of physician-diagnosed diabetes among adults aged 20 and over increased from 5.2% in 1988-1994 to 8.4% in 2009-2012.

- The prevalence of obesity among adults (aged 20–74) increased by almost three-fold from 1960–1962 (13.4% of adults classified as obese) to 2009–2010 (36.1% of adults classified as obese).

- In the past 30 years, obesity has more than doubled in children and quadrupled in adolescents in the United States. The percentage of

> children aged 6–11 who were obese increased from 7% in 1980 to nearly 18% in 2012. Similarly, the percentage of adolescents aged 12–19 years who were obese increased from 5% to nearly 21% over the same period. In 2012, approximately one-third of American children and adolescents were overweight or obese.

Health status is often associated with demographics and socioeconomic status. Changes in the overall size of the population, racial and ethnic composition, and age distribution affect the health status of the population. Poverty, educational attainment, access to care, and discrimination all contribute to disparities in the incidence and prevalence of a variety of medical conditions. Some examples of these interactions include:

Olders

In 2013, the percentage of adults age 75 and older described as persons in fair or poor health totaled 27.6%, as compared to 6.2% for adults age 18 to 44 (Heo et al. 2008).Among adults age 65 and older, the number in nursing homes or other residential care facilities totaled 1.8 million in 2012, with more than 1 million utilizing home health care.

Figure 14: Showing Approximately 9% Asthmatic Problem

Children

Approximately 9.0% of children in the United States have asthma (Moorman et al 2012). Between 2011 and 2013, rates for Black (15.3%) and Hispanic (8.6%) children were higher than the rate for White (7.8%) children. Rates of asthma were also higher in poor children who live below 100% of the poverty level (12.4%) (Figure 14).

Non-Hispanic Blacks

In 2014, the percentage of non-Hispanic Blacks of all ages who were described as persons in fair or poor health totaled 14.3% as compared to 8.7% for Whites. Health risk factors for this population include high rates of smoking, obesity, and hypertension in adults, as well as high infant death rates (NCHS 2015).

Hispanics

The percentage of Hispanics of all ages who were described as persons in fair or poor health totaled 12.7% in 2014 (NRC 2006). Health disparities for Hispanics include moderately higher rates of smoking in adults, low birth weights, and infant deaths.

The impacts of climate change may worsen these health disparities by exacerbating some of the underlying conditions they create. For example, disparities in life expectancy may be exacerbated by the effects of climate change related heat and air pollution on minority populations that have higher rates of hypertension, smoking, and diabetes (Table 1). Conversely, public health measures that reduce disparities and overall rates of illness in populations would lessen vulnerability to worsening of health status from climate change effects.

Table 1: Current estimates and future trends in chronic health conditions that interact with the health risks associated with climate change

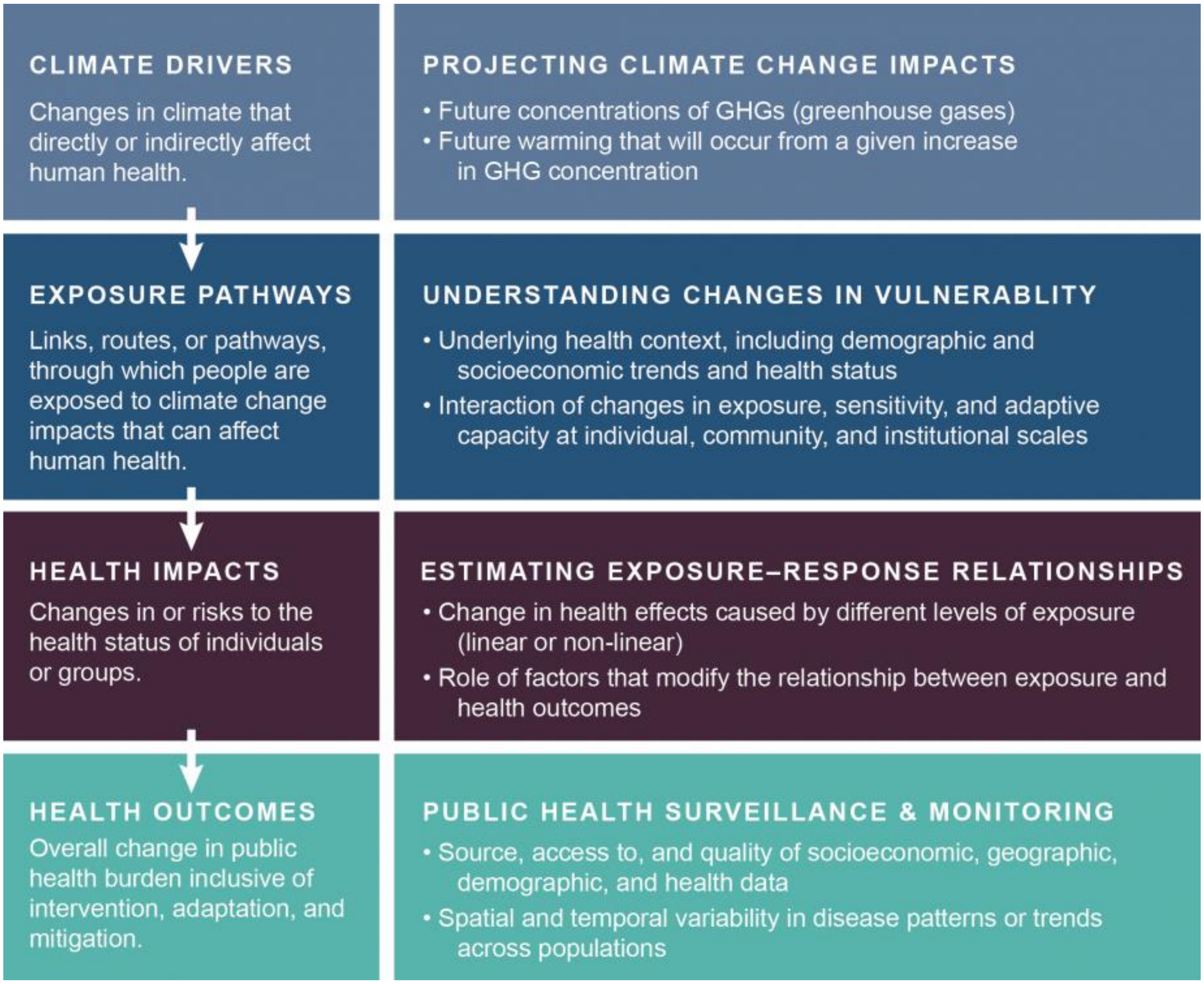
Health Conditions	**Current Estimates**	**Future Trends**
ASTHMA	Average asthma prevalence in the U.S. was higher in children (9% in 2014) than in adults (7% in 2013).[35] Since the 1980s, asthma prevalence increased, but rates of asthma deaths and hospital admissions declined.[,]	Stable incidence and increasing prevalence of asthma is projected in the U.S. in coming decades.
CHRONIC OBSTRUCTIVE PULMONARY DISEASE (COPD)	In 2012, approximately 6.3% of adults had COPD. Deaths from chronic lung diseases increased by 50% from 1980 to 2010.[38,]	Chronic respiratory diseases are the third leading cause of death and are expected to become some of the most costly illnesses in coming decades. [38]
DIABETES	In 2012, approximately 9% of the total U.S. population had diabetes. Approximately 18,400 people younger than age 20 were newly diagnosed with type 1 diabetes in 2008–2009;	New diabetes cases are projected to increase from about 8 cases per 1,000 in 2008 to about 15 per 1,000 in 2050. If recent increases continue, prevalence is projected to increase to 33% of Americans by 2050.

Health Conditions	Current Estimates	Future Trends
	an additional 5,000 were diagnosed with type 2.	
CARDIOVASCULAR DISEASE	Cardiovascular disease (CVD) is the leading cause of death in the U.S.	By 2030, approximately 41% of the U.S. population is projected to have some form of CVD.
MENTAL ILLNESS	Depression is one of the most common types of mental illness, with approximately 7% of adults reporting a major episode in the past year. Lifetime prevalence is approximately twice as high for women as for men. Lifetime prevalence is more than 15% for anxiety disorders and nearly 4% for bipolar disorder.[45]	By 2050, the total number of U.S. adults with depressive disorder is projected to increase by 35%, from 33.9 million to 45.8 million, with those over age 65 having a 117% increase.
OBESITY	In 2009–2010, approximately 35% of American adults were obese.[32] In 2012, approximately 32% of youth (aged 2–19) were overweight or obese.[46,47]	By 2030, 51% of the U.S. population is expected to be obese. Projections suggest a 33% increase in obesity and a 130% increase in severe obesity.[48]

Health Conditions	Current Estimates	Future Trends
DISABILITY	Approximately 18.7% of the U.S. population has a disability. In 2010, the percent of American adults with a disability was approximately 16.6% for those age 21–64 and 49.8% for persons 65 and older.	The number of older adults with activity limitations is expected to grow from 22 million in 2005 to 38 million in 2030.

18. UNCERTANITY ON HUMAN HEALTH

For some changes in exposures to health risks related to climate change, the future rate of a health impact associated with any given environmental exposure can be estimated by multiplying three values: 1) the baseline rate of the health impact, 2) the expected change in exposure, and 3) the exposure–response function. An exposure–response function is an estimate of how the risk of a health impact changes with changes in exposures, and is related to sensitivity, one of the three components of vulnerability. For example, an exposure–response function for extreme heat might be used to quantify the increase in heat-related deaths in a region (the change in health impact) for every 1°F increase in daily ambient temperature.



CLIMATE DRIVERS

Changes in climate that directly or indirectly affect human health.

PROJECTING CLIMATE CHANGE IMPACTS

- Future concentrations of GHGs (greenhouse gases)
- Future warming that will occur from a given increase in GHG concentration

EXPOSURE PATHWAYS

Links, routes, or pathways, through which people are exposed to climate change impacts that can affect human health.

UNDERSTANDING CHANGES IN VULNERABLITY

- Underlying health context, including demographic and socioeconomic trends and health status
- Interaction of changes in exposure, sensitivity, and adaptive capacity at individual, community, and institutional scales

HEALTH IMPACTS

Changes in or risks to the health status of individuals or groups.

ESTIMATING EXPOSURE–RESPONSE RELATIONSHIPS

- Change in health effects caused by different levels of exposure (linear or non-linear)
- Role of factors that modify the relationship between exposure and health outcomes

HEALTH OUTCOMES

Overall change in public health burden inclusive of intervention, adaptation, and mitigation.

PUBLIC HEALTH SURVEILLANCE & MONITORING

- Source, access to, and quality of socioeconomic, geographic, demographic, and health data
- Spatial and temporal variability in disease patterns or trends across populations

Figure 15 : Examples of sources of uncertainty in projecting impacts of climate change on human health. The left column illustrates the exposure pathway through which climate change can affect human health. The right column lists examples of key sources of uncertainty surrounding effects of climate change at each stage along the exposure pathway.

Two of the key uncertainties in projecting future global temperatures are 1) uncertainty about future concentrations of greenhouse gases, and 2) uncertainty about how much warming will occur for a given increase in greenhouse gas concentrations. The Intergovernmental Panel on Climate Change's Fifth Assessment Report found that the most likely response of the climate system to a doubling of carbon dioxide concentrations lies between a 1.5 and 4.5 (2.7°F to 8.1°F) increase in global average temperature (Ackeman et al. 2008). Future concentrations depend on both future emissions and how long these emissions remain in the atmosphere. To capture these uncertainties, climate modelers often use multiple models, analyze multiple scenarios, and conduct sensitivity analyses to assess the significance of these uncertainties.

Uncertainty in current and future estimates of health or socioeconomic status is related to several factors. In general, estimates are more uncertain for less-prevalent health conditions (such as rare cancers versus cardiovascular disease, Kosaez 2014), smaller subpopulations (such as Hispanic subpopulations versus White adults), smaller geographic areas (census tracts versus state or national scale), and time periods further into the future (decades versus seasons or years). Most current estimates of disease prevalence or socioeconomic status have uncertainty expressed as standard errors or confidence intervals that are derived from sampling methods and sample sizes. When modeling impacts using data on health prevalence or socioeconomic status, these measures of uncertainty are typically included in the analysis to help establish a range of plausible results (Luber 2014) climate change. Expert judgment is typically used to assess the overall effects of uncertainty from estimates of health or socioeconomic status when assessing the scientific literature.

The factors related to uncertainty in exposure–response functions are similar to those for the projections of health or socioeconomic status. Estimates are more uncertain for smaller subpopulations, less-prevalent health conditions, and smaller geographic areas. Because these estimates are based on observations of real populations, their validity when applied to populations in the future is more uncertain the further into the future the application occurs. Uncertainty in the estimates of the exposure–outcome relationship also comes from factors related to the scientific quality of relevant studies, including appropriateness of methods, source of data, and size of study populations (Figure 15). Expert judgment is used to evaluate the validity of an individual study as well as the collected group of relevant studies in assessing uncertainty in estimates of exposure–outcome relationships.

19. IMPORTANT OF GREEN HOUSE GASES (GHGs)

The most common and most talked about greenhouse gases is CO2 or carbon dioxide. In fact, because it is so common, scientists use it as the benchmark or measure of things that warm the atmosphere (Auffhammer et al. 2006, Samras et al. 2008).

Methane, another important GHG, for example, is 28-36 times as warming as CO2 when in the upper atmosphere (USEPA GWP – Global Warming Potential – estimate over 100 years), therefore, 1 ton of methane = 28-36 tons eCO2 or CO2 equivalents.

The most commonly discussed GHGs are:

- CO2 or carbon dioxide is produced any time something is burned. It is the most common GHG, constituting by some measures almost 55% of total long-term GHGs. It is used as a marker by the United States Environmental Protection Agency, for example, because of its ubiquity. Carbon dioxide is assigned a GWP or Global Warming Potential of 1.

- Methane or CH4 is produced in many combustion processes and also by anaerobic decomposition, for example, in flooded rice paddies, pig and cow stomachs, and pig manure ponds. Methane breaks down in approximately 10 years, but is a precursor of ozone, itself an important GHG. CH4 has a GWP of 28-36.

- Nitrous oxide in parean (laughing gas), NO/N2O or simply NOx is a byproduct of fertilizer production and use, other industrial processes and the combustion of certain materials. Nitrous oxide lasts a very long time in the atmosphere, but at the 100 year point of comparison to CO2, its GWP is 265-298.

- Fluorinated gases were created as replacements for ozone depleting refrigerants, but have proved to be both extremely long lasting and extremely warming GHGs. They have no natural sources, but are entirely man-made. At the 100 year point of comparison, their GWPs range from 1,800 to 8,000 and some variants top 10,000.

- Sulphur hexafluoride or SF6 is used for specialized medical procedures, but primarily in what are called dielectric materials, especially dielectric liquids. These are used as insulators in high voltage applications such as transformers and grid switching gear. SF6 will last thousands of years in the upper atmosphere and has a GWP of 22,800.

Sources of GHGs and black carbon

Fossil fuel and related uses of coal and petroleum are the most important sources of GHGs and black carbon (power generation, industry, transportation, buildings). What evidence do we have of climate change?
The most compelling climate change evidence scientists have of climate change is long term data relating atmospheric CO2 levels and global temperature, sea level, the expanse of ice, the fossil record and the distribution of species.

This data, which goes back millions of years, shows a strong correlation between CO2 levels and temperature. Recent data shows a trend of increasing temperature and rising CO2 levels beginning in the early 19th century.

Because all parts of the global climate are connected, scientists have been able to create models of how changes caused by heating should work their way through the entire system and appear in different areas, for example, sea level, intemperate weather, the movement of fish species in the ocean.

A second way to test is to use the model to predict upcoming changes and then to see if emerging reality fits. It is possible to track the rapid retreat of glaciers and observe the summer melting of the Polar Ice Cap. Sea levels are rising measurably, the temperature of the world's oceans is demonstrably rising and consequently many fish species are moving to follow waters that are the right temperature for them (Rayner et al 2005).

The Correlating of these changes to the timing of rises in CO2 levels and temperature suggests relationship. NASA provides a good visual tool for viewing these relational models "in action".

Agriculture is the second most important source (animals – cows and pigs), feed production, chemical intensive food production, and flooded paddy rice production, as well as deforestation driven by the desire to expand cultivated areas (Santilli et al. 2005).

Despite the apparent scientists view consensus among scientists, NGOs, international organizations, policy makers and the media, there are respected scientists who remain “climate sceptics,” that is, who doubt that the overall theory of human induced global climate change is correct, or that the observed phenomena demonstrate conclusively that it is, or that the observed phenomena are anything out of the ordinary (viewed in the time frame of “earth history”).

It is important to separate these scientists from ‘sceptics’ who have a financial interest in denying climate change. These people have been important in framing the climate change debate in the United States and the position of the United States government on the issue of climate change. Their success has little to do with alternative science, however, and everything to do with the permeability of the US political process to the influence of such actors.

It is also important to separate these scientists from the ignorant and people who do not understand evidence-based science. Such people are simply uninformed or misinformed, make such ignorant statements as “it’s just a theory” or cite isolated facts as if they mattered. Their numbers have made this group politically powerful in the US, but their ignorance sidelines them in the global debate.

Climate sceptics fall into three camps: those like Freeman Dyson, Bjorn Lomborg and Kiminori Itoh who acknowledge climate change, but think that carbon-based theory and current models are too simplistic to capture such a complex process; those like Ivar Giaever who think that the data is too thin to support such bold claims; and those like Will Happer who contend that the nice analogy of a greenhouse does not apply and that CO2 is too insignificant to be the culprit.

An article prepared to accompany a petition urging the US not to sign global climate accords reviews each of the main contentions of climate change scientists view and presents data suggesting that each is wrong. The authors of the article cite data, for example, that suggests that the earth's temperature today is essentially at the 3,000-year average global temperature, while during the Medieval period, long before the use of fossil fuels, temperatures were 24^0 C higher.

In a similar vein, they cite data to suggest that glacier shortening began in the early 19th century, 25 years before the start of intensive fossil fuel use. For a more recent web piece by a well-informed, non-scientist sceptic, see David Siegel's "scientists view on global warming"

20. **AGRICULTURE PESTS, DISEASE AND DISEASE VECTORS**

Pest populations are on the rise and illnesses once found only in limited, tropical areas are now becoming endemic in much wider zones. In Southeast Asia, for example, where malaria had been reduced to a wet season only disease in most areas, it is again endemic almost everywhere year around. Likewise, dengue fever, once largely confined to tropical areas, has become endemic to the entire region.

Increased temperatures also increase the reproduction rates of microbes and insects, speeding up the rate at which they develop resistance to control measures and drugs (a problem already observed with malaria in Southeast Asia). To date, the effort to manage climate change has been a matter of high level diplomatic negotiations involving states and international organizations with a loud, but largely excluded fringe of NGOs, business groups, and minor political actors. The logic for this is that global climate change affects us all, but individual countries can manage only the activities that take place within their borders; to confront a global problem, we need a global solution. As the United Nations history of these negotiations begins:
"Climate change is a global challenge and requires a global solution. Greenhouse gas emissions have the same impact on the atmosphere whether they originate in Washington, London or Beijing. Consequently, action by one country to reduce emissions will do little to slow global warming unless other countries act as well (Satterthwaite 2008). Ultimately, an effective

strategy will require commitments and action by all the major emitting countries." The global effort to manage climate change has been organized through what is called the United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC was launched at the 1992 Rio Earth Summit to achieve GHG concentrations.

With the failure of the Rio initiatives, the then 191 signatories to the UNFCCC agreed to meet in Kyoto in 1997 to establish a more stringent regime. The resulting Kyoto Protocol created a global trading system for carbon credits and binding GHG reductions for ratifying countries. (The US did not sign; China and India were exempt as developing countries.) So-called Conferences of the Parties (COPs) were held almost annually thereafter in places such as The Hague, Cancun and Doha without progress being made. (Following the failure of the 2012 Doha meetings, the unrenewed Kyoto carbon trading system collapsed.)

Managing climate change difficulties arise from two, related reasons: climate change management is viewed as expensive and it poses what we call a collective action problem. When business and politicians talk about climate change, the first thing they mention is cost. If you start from the status quo today, adding CO2 removing equipment to a coal power plant is expensive – but only if you do not value the environment. When you buy coal for a power plant, you pay for a limited resource and the cost of supplying it to you.

Today, when you dump the GHGs and black carbon from burning coal into the air, you pay nothing. But a clean atmosphere is a limited resource; the atmosphere will absorb only so much GHGs and black carbon before it is not clean, at which point it is costly to clean it. Logically, there is no reason why businesses that pay for a scarce resource like coal as an input should not pay for a scarce resource like the environment as a disposal site.

This is called "costing" or "accounting" the environment. If the environment is included among the basic costs of doing business that all businesses plan into their profit and loss statements, then "managing climate change" would no longer be an expensive extra. It would be a standard cost of doing business.

21. IMPACT OF VULNERABILITY OF CLIMATE CHANGE ON GLOBAL ISSUES

Power

Most power is generated in the developed world, much using old, dirty technology and carried long distances over inefficient power grids. Developing countries have the opportunity to build entirely new, distributed generation power systems that require no grids and use non-polluting technologies.

Industry

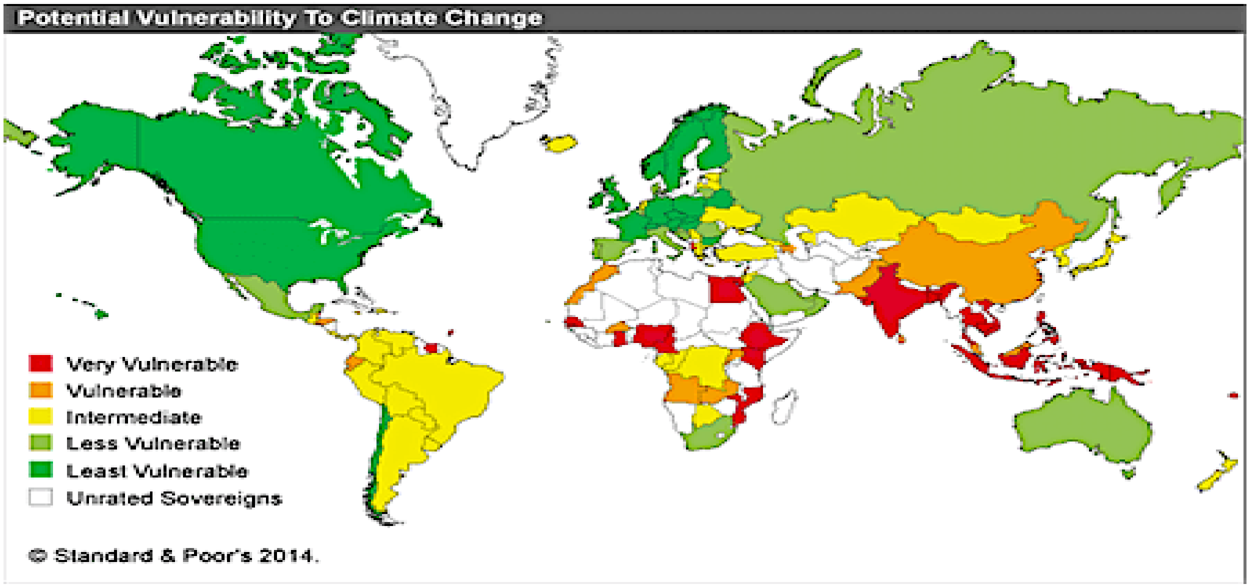
Building green field industrial economies, developing countries have the opportunity to cost the environment and construct with non-polluting technologies.

Transportation

Not yet entirely dependent upon massive road-based transportation infrastructures, developing countries have the opportunity to design efficient, low-cost, high volume transportation systems to serve cities and industrial centers, and to use policy incentives to discourage personal automobile ownership and construct high quality public transportation systems.

Building

And because so much existing building stock must be replaced in short order, developing countries have the opportunity to build efficiency into individual structures and to design urban areas for high density, high energy efficiency living.


Potential Vulnerability To Climate Change

© Standard & Poor's 2014.

Figure 16: Showing the impact of vulnerability of climate change on global issues.

The effects of global warming are already bringing harm to human communities and the natural world. Further temperature rises will have a devastating impact and more action on greenhouse gas emissions is urgently required (Figure 16).

Population and climate change are directly linked. Every additional person increases carbon emissions — the rich more than the poor — and increases the number of climate change victims – the poor more than the rich (Shi 2003).

22. THE CLIMATE CHANGE THREAT

Further warming of our atmosphere is now almost impossible to avoid. The effects of that warming will depend on how high and how fast the temperature rises. Global warming changes weather patterns, causing severe weather events, heat waves, droughts and floods.

Climate change is already shrinking glaciers and ice caps, altering the availability of fresh water. It contributes to ocean acidification, destroying coral reefs and other aquatic ecosystems. It makes places uninhabitable for some plants and animals, leading to extinctions and redistribution of species, threatening food production with alien pests and diseases.

Its potential human cost is catastrophic. A rise in sea levels threatens hundreds of millions of people in coastal communities and cities across the globe. Food and water shortages and conflict over productive land will arise, while progress in global health could be rolled back by communicable diseases such as malaria reaching places they never existed before. Hundreds of millions of people are likely to be forced to migrate from their homes by 2050.

Climate change action

Reducing the number of people being born cuts future carbon emissions, effectively, simply and permanently. That is not the only action needed - technological solutions, personal lifestyle changes, policies to end fossil fuel use and develop alternative energy and potentially fundamental changes to our economic ssytems are all vital. The positive impact of each of those, however, is reduced and may even be completely cancelled out by adding emissions from hundreds of millions of new people as our population increases.

The 2019 Scientists' Warning of a Climate Emergency, signed by more than 13,000 scientists from around the world, explicitly calls for "bold and drastic transformations" regarding both economic and population policies, including making family planning services available to all and achieving full gender equity.

Individual actions

A study published in 2017 by the Universities of Lund and British Columbia suggested that the single most effective measure an individual in the developed world could take to cut their carbon emissions over the long term could be to have one fewer child. While future per capita carbon emissions are impossible to predict, illustrative figures produced by the authors suggested it could be more than 20 times more effective than the next most effective measure, living without a car.

All the benefits of this action are not immediate and it does not mean that we should not take other actions to cut our individual carbon footprints, of course. Choosing a small family can make a vital contribution, however.

Global policy

Another major international study in 2017 identified practical policy measures that could be taken to minimise greenhouse gas emissions as quickly as possible. Project Drawdown analysed more than eighty policy options, such as plant-based diets, solar farms and electric vehicles.

The study identified family planning and educating girls as among the top 10 workable solutions to combat climate change available today. It found that together, they would reduce CO2 emissions by 103 gigatons by 2050 — more than onshore and offshore wind power combined. Their enormous positive effect is a result of their proven effectiveness in reducing family size and population growth.

Population action

Because individuals in the developed world have the greatest impact each, people choosing to have smaller families in the richest parts of the world will have the greatest and most immediate positive effect – a vital choice given the urgency to address which climate change. Furthermore, reduced emissions as a result of fewer people being born in richer countries allow more economic development in poorer countries without adding to total emissions.

However, in poorer countries, including those where population growth is highest, economic development is increasing individual carbon footprints and rapidly growing populations push emissions still higher. In its landmark 2018 report, the International Panel on Climate Change specifically identified high population growth as a "key impediment" to hitting the critical target of limiting global warming to 1.5°C.

Nations with very high populations such as India and China are among the most significant contributors to climate change overall, despite relatively lower impacts from each individual. While India and China have relatively low population growth, people born today in countries whose populations are still expanding rapidly will have a climate impact for generations to come.

There are many ethical, effective means of achieving a sustainable population. In addition to family planning, girls' education and other measures to empower women, people need to be educated about the personal and global benefits of smaller families, while beliefs and values favouring large families must be overturned. All these measures will help reduce family size and bring population growth to an end as soon as possible - giving us all the best chance of limiting climate change and protecting the next generation.

23. CLIMATE CHANGE AND AGRICULTURE

The broad subtopics considered in this section are cropping systems, pasture and grazinglands, and animal management. The many U.S. crops and livestock varieties (valued at about $200 billion in 2002) are grown in diverse climates, regions, and soils. No matter the region, however, weather and climate factors such as temperature, precipitation, CO_2 concentrations, and water availability directly impact the health and well-being of plants, pasture, rangeland, and livestock. For any agricultural commodity, variation in yield between years is related to growing-season weather; weather also influences insects, disease, and weeds, which in turn affect agricultural production.

- With increased CO_2 and temperature, the life cycle of grain and oilseed crops will likely progress more rapidly. But, as temperature rises, these crops will increasingly begin tto experience failure, especially if climate variability increases and precipitation lessens or becomes more variable.

- The marketable yield of many horticultural crops – e.g., tomatoes, onions, fruits – is very likely to be more sensitive to climate change than grain and oilseed crops.

- Climate change is likely to lead to a northern migration of weeds. Many weeds respond more positively to increasing CO_2 than most cash crops, particularly C3 "invasive" weeds. Recent research also suggests that glyphosate, the most widely used herbicide in the United States, loses its efficacy on weeds grown at the increased CO_2 levels likely in the coming decades.

- Disease pressure on crops and domestic animals will likely increase with earlier springs and warmer winters, which will allow proliferation and higher survival rates of pathogens and parasites. Regional variation in warming and changes in rainfall will also affect spatial and temporal distribution of disease main reasons to assess changes in ecosystems is to understand the consequences of those changes for the delivery of services that our society values. There are many analyses of the impacts of climate change on individual species and ecosystems in the scientific literature, but there is not yet adequate integrated analysis of how climate change could affect ecosystem services.

- A comprehensive understanding of impacts on these services will only be possible through quantification of anticipated alterations in ecosystem function and productivity. As described by the Millennium Ecosystem Assessment, some products of ecosystems, such as food and fiber, are priced and traded in markets. Excellent models already exist in China, Korea and Singapore, and even the medium-term cost savings are so great that not investing to do better than the developed world today is foolish.

24. ROLE OF HUMAN CONTRIBUTION TO CLIMATE CHANGE NOT INCLUDING GLOBAL WARMING

Global warming results within the warmth of the earth which results climate change. On some very hot days, plants will mess up during photosynthesis and release more CO_2 out. CO_2 rising emissions will warm the land and polar ice capping will melt. The oceans take in CO_2 as certain animals/ plants need it. When the ocean has too much CO_2 in it, it became acidic and demolish marine life such as coral. With ice capping melting, polar bears have less space to hunt and eventually die off.

Additionally, as the ice capping melt, the earth warms quicker since there is no where for the heating to balance and go to as the earth warms more. Hotter temperatures will also create more droughts, the creation of more forest fires. The forests will eventually transform into desserts and different animals will have to adjust live their lives.

25. ROLE OF DEVELOPING OF WORLD REDUCE ITS OWN IMPACT ON CLIMATE CHANGE

Improve agriculture. Globally, agriculture accounts for approximately one third of total GHG and black carbon emissions; the developing world, however, produces a disproportionate amount of this total – Asia and Africa between them producing 59% of the total. While developed country contributions have dropped as a result of reduced biomass burning and reduced agrochemical use per unit, developing country contributions have risen. (In 1990, for example, Europe's contribution was 21% and Asia's 38%; today, Europe contributes 12% and Asia 44%)
Three immediate steps of climate change stand out are as Follows:

- First, rice production in the developing world, largely in Asia, which grows 90% of the world's rice, needs to switch from flooded paddy propagation to SRI (system for rice intensification) techniques. This will largely eliminate the tremendous amount of methane produced by anaerobic decomposition in flooded paddies that alone contributes 10% of global GHGs annually.

- Second, developing countries need to control the practice of the open field burning of agricultural wastes (rice straw, corn stalks), which annually contributes millions of tons of CO_2 and black carbon to global warming.

- Third, developing countries need to develop aggressive national programs to promote the transformation of field wastes into biochar, which will sequester millions of tons of CO_2 annually and eliminate both particulate and GHG emissions, while adsorbing NO_x and other fertilizer derives emissions if added to soil.

- Climate change-induced shifts in plant species are already under way in rangelands. Establishment of perennial herbaceous species is reducing soil water availability early in the growing season. Shifts in plant productivity and type will likely also have significant impact on livestock operations.

Higher temperatures will very likely reduce livestock production during the summer season, but these losses will very likely be partially offset by warmer temperatures during the winter season. For ruminants, current management systems generally do not provide shelter to buffer the adverse effects of changing climate; such protection is more frequently available for non-ruminants (e.g., swine and poultry).

Monitoring systems for measuring long-term response of agricultural lands are numerous, but integration across these systems is limited. Existing state-and-transition models could be expanded to incorporate knowledge of how agricultural lands and products respond to global change; integration of such models with existing monitoring efforts and plant developmental data bases could provide cost-effective strategies that both enhance knowledge of regional climate change impacts and offer ecosystem management options. In addition, at present, there are no easy and reliable means to accurately ascertain the mineral and carbon state of agricultural lands, particularly over large areas; a fairly low-cost method of monitoring biogeochemical response to global change would be to sample ecologically important target species in different ecosystems.

Land Resources

- The broad subtopics considered in this section are forest lands and arid lands. Climate strongly influences forest productivity, species composition, and the frequency and magnitude of disturbances that impact forests. The effect of climate change on disturbances such as forest fire, insect outbreaks, storms, and severe drought will command public attention and place increasing demands on management resources. Disturbance and land use will control the response of arid lands to climate change. Many plants and animals in arid ecosystems are near their physiological limits for tolerating temperature and water stress and even slight changes in stress will have significant consequences. In the near term, fire effects will trump climate effects on ecosystem structure and function.

- Climate change has very likely increased the size and number of forest fires, insect outbreaks, and tree mortality in the interior West, the Southwest, and Alaska, and will continue to do so.

- Rising CO2 will very likely increase photosynthesis for forests, but this increase will likely only enhance wood production in young forests on fertile soils.

- Nitrogen deposition and warmer temperatures have very likely increased forest growth where adequate water is available and will continue to do so in the near future.

- The combined effects of rising temperatures and CO2, nitrogen deposition, ozone, and forest disturbance on soil processes and soil carbon storage remains unclear (Tilmes et al. 2008).

- Higher temperatures, increased drought, and more intense thunderstorms will very likely increase erosion and promote invasion of exotic grass species in arid lands.

- Climate change in arid lands will create physical conditions conducive to wildfire, and the proliferation of exotic grasses will provide fuel, thus causing fire frequencies to increase in a self-reinforcing fashion In arid regions where ecosystems have not coevolved with a fire cycle, the probability of loss of iconic, charismatic megaflora such as saguaro cacti and Joshua trees is very likely.

- Arid lands very likely do not have a large capacity to absorb CO2 from the atmosphere and will likely lose carbon as climate induced disturbance increases.

- River and riparian ecosystems in arid lands will very likely be negatively impacted by decreased stream flow, increased water removal, and greater competition from nonnative species.

- Changes in temperature and precipitation will very likely decrease the cover of vegetation that protects the ground surface from wind and water erosion.

- Current observing systems do not easily lend themselves to monitoring change associated with disturbance and alteration of land cover and land use, and distinguishing such changes from those driven by climate change. Adequately distinguishing climate change influences is aided by the collection of data at certain spatial and temporal resolutions, as well as supporting ground truth measurements.

The broad subtopics considered in this section are water quantity and water quality. Plants, animals, natural and managed ecosystems, and human settlements are susceptible to variations in the storage, fluxes, and quality of water, all of which are sensitive to climate change (Backlund et al. 2008). The effects of climate on the nation's water storage capabilities and hydrologic functions will have significant implications for water management and planning as variability in natural processes increases.

Although U.S. water management practices are generally quite advanced, particularly in the West, the reliance on past conditions as the foundation for current and future planning and practice will no longer be tenable as and variability increasingly create conditions well outside of historical parameters and erode predictability (Baken 1990, 2004). Most of the United States experienced increases in precipitation and stream flow and decreases in drought during the second half of the 20th century. It is likely that these trends are due to a combination of decadal scale variability and long-term change.

- Consistent with stream flow and precipitation observations, most of the continental United States experienced reductions in drought severity and duration over the 20th century. However, there is some indication of increased drought severity and duration in the western and southwestern United States.

- There is a trend toward reduced mountain snowpack and earlier spring snowmelt runoff peaks across much of the western United States. This trend is very likely attributable at least in part to long-term warming, although some part may have been played by decadal-scale variability, including a shift in the phase of the Pacific Decadal Oscillation in the late 1970s. Where earlier snowmelt peaks and reduced summer and fall low flows have already been detected, continuing shifts in this direction are very likely and may have substantial impacts on the performance of reservoir systems.

- Water quality is sensitive to both increased water temperatures and changes in precipitation. However, most water quality changes observed so far across the continental United States are likely attributable to causes other than climate change.

- Stream temperatures are likely to increase as the climate warms, and are very likely to have both direct and indirect effects on aquatic ecosystems. Changes in temperature will be most evident during low flow periods, when they are of greatest concern. Stream temperature increases have already begun to be detected across some of the United States, although a comprehensive analysis similar to those reviewed for stream flow trends has yet to be conducted. Stream temperatures are likely to increase as the climate warms, and are very likely to have both direct and indirect effects on aquatic ecosystems.

The Effects of Climate Change on Agriculture, Land Resources, Water Resources, Biodiversity

The broad subtopics considered in this section are species diversity and rare and sensitive ecosystems. Biodiversity, the variation of life at the genetic, species, and ecosystem levels of biological organization, is the fundamental building block of the services that ecosystems deliver to human societies. It is intrinsically important both because of its contribution to the functioning of ecosystems, and because it is difficult or impossible to recover or replace, once it is eroded. Climate change is affecting U.S. biodiversity and ecosystems, including changes in growing season, phenology, primary production, and species distributions and diversity. It is very likely that climate change will increase in importance as a driver for changes in biodiversity over the next several decades, although for most ecosystems it is not currently the largest driver of change. There has been a significant lengthening of the growing season and increase in net primary productivity (NPP) in the higher latitudes of North America. Over the last 19 years, global satellite data indicate an earlier onset of spring across the temperate latitudes by 10 to 14 days.

In an analysis of 866 peer-reviewed papers exploring the ecological consequences of climate change, nearly 60 percent of the 1598 species studied exhibited shifts in their distributions and/or phenologies over the 20- and 140-year time frame. Analyses of field based phenological responses have reported shifts as great as 5.1 days per decade, with an average of 2.3 days per decade across all species.

Subtropical and tropical corals in shallow waters have already suffered major bleaching events that are clearly driven by increases in sea surface temperatures. Increases in ocean acidity, which are a direct consequence of increases in atmospheric carbon dioxide, are calculated to have the potential for serious negative consequences for corals.

The rapid rates of warming in the Arctic observed in recent decades, and projected for at least the next century, are dramatically reducing the snow and ice covers that provide denning and foraging habitat for polar bears. There are other possible, and even probable, impacts and changes in biodiversity (e.g.,disruption of the relationships between pollinators, such as bees, and flowering plants), for which we do not yet have a substantial observational database. However, we cannot conclude that the lack of complete observations is evidence that changes are not occurring.

It is difficult to pinpoint changes in ecosystem services that are specifically related to changes in biological diversity in the United States. A specific assessment of changes in ecosystem services for the United States as a consequence of changes in climate or other drivers of change has not been done. The monitoring systems that have been used to evaluate the relationship between changes in the physical climate system and biological diversity have three components: species pacific or ecosystem-specific monitoring systems, research activities specifically designed to create time-series of population data and associated climatic and other environmental data, and spatially extensive observations derived from remotely sensed data. However, in very few cases were these monitoring systems established with climate variability and climate change in mind, so the information that can be derived from them specifically for climate-change-related studies is somewhat limited. It is also not clear that existing networks can be maintained for long enough to enable careful time-series studies to be conducted.

25. GLOBAL CLIMATE CONTEXT

There is a robust scientific consensus that human-induced climate change is occurring. The recently released Fourth Assessment Report of the IPCC (IPCC AR4) states with “very high confidence,” that human activity has caused the global climate to warm. Many well-documented observations show that fossil fuel burning, deforestation, and other industrial processes are rapidly increasing the atmospheric concentrations of CO2 and other greenhouse gases. The IPCC report describes an increasing body of observations and modeling results, summarized below, which show that these changes in atmospheric composition are changing the global climate and beginning to affect terrestrial and marine ecosystems (Anderson et al 1999). The global-average surface temperature increased by about 0.6°C over the 20th century. Global sea level increased by about 15-20 cm during this period.

While droughts can have different causes depending on the area of the world and other natural factors, the majority of scientists have started to link more intense droughts to climate change (Anderiadis et al. 2006). That’s because as more greenhouse gas emissions are released into the air, causing air temperatures to increase, more moisture evaporates from land and lakes, rivers, and other bodies of water . Warmer temperatures also increase evaporation in plant soils, which affects plant life and can reduce rainfall even more. And when rainfall does come to drought-stricken areas, the drier soils it hits are less able to absorb the water, increasing the likelihood of flooding – a lose-lose situation.

26. ECOLOGICAL AND BIOLOGICAL CONTEX

Climate variability and change have many impacts on terrestrial and marine ecosystems. Ecosystem responses to climate have implications for sustainability, biodiversity, and the ecosystem goods and services available to society. Some of these impacts affect the biological systems only, but some create further feedbacks to the climate system through greenhouse gas fluxes, albedo changes, and other processes. Much research on terrestrial ecosystems and climate change has focused on their role as carbon sources or sinks. The observation that atmospheric CO2 was increasing more slowly than expected from fossil fuel use and ocean uptake led to the speculation of a "missing sink," and the conclusion that increased plant photosynthesis was due to elevated atmospheric CO2 (Gifford et al. 1994). It is now evident that several mechanisms, and not just CO2 fertilization, contribute to the 'missing sink' (Field et al. 2007). These mechanisms include recovery from historic land use, fertilizing effects of nitrogen in the environment, expansion of woody vegetation ranges, storage of carbon in landfills and other depositional sites, and sequestration in long lived timber products (Schimel et al. 2001). Responses of photosynthesis and other processes that contribute to overall plant growth to warming are nonlinear. Each process (e.g., Comprehensive analyses show that climate change is already causing the shift of many species to higher latitudes and/or altitudes, as well as changes in phenology. Not all species can successfully adjust, and some models suggest that biomes that are shifting in a warm, high-CO2 world lose an average of a tenth of their biota.

Climate will affect ecosystems through fire, pest outbreaks, diseases, and extreme weather, as well as through changes to photosynthesis and other physiological processes. Disturbance regimes are a major control of climate-biome patterns. Fire-prone ecosystems cover about half the land area where forests would be expected, based on climate alone, and lead to grasslands and savannas in some of these areas. Plant pathogens, and insect defoliators are pervasive as well, and annually affect more than 40 times the acreage of forests in the United States damaged by fire. Disturbance modifies the climatic conditions where a vegetation type can exist.

While much of the ecosystems and climate change literature focuses on plants and soil processes, significant impacts on animal species are also known. A substantial literature documents impacts on the timing of bird migrations, on the latitudinal and elevational ranges of species and on more complex interactions between species, e.g., when predator and prey species respond to climate differently, breaking their relationships (Parmesan and Yohe 2003). The seasonality of animal processes may also respond to changes in climate, and this effect can have dramatic consequences, as occurs, for example, with changes in insect pest or pathogen-plant host interactions. Domestic animals also respond significantly to climate, both through direct physiological impacts on livestock, and through more complex effects of climate on livestock and their habitats.

Marine and coastal ecosystems are similarly sensitive in general to variability and change in the physical climate system, and in some cases directly to atmospheric concentrations of carbon dioxide. Fish populations in major large marine biomes are known to shift their geographic ranges in response to specific modes of climate variation, such as the Pacific Decadal Oscillation and the North Atlantic Oscillation, and there have been shifts in geographical range of some fish species in response to surface water warming over the past several decades on both West and East coasts of North America. Subtropical and tropical corals in shallow waters have already suffered major bleaching events that are clearly driven by increases in sea surface temperatures, and increases in ocean acidity, which are a direct consequence of increases in atmospheric carbon dioxide, are calculated to have the potential for serious negative consequences for corals. Many studies on climate impacts on ecosystems look specifically at impacts only of variation and change in the physical climate system and CO2 concentrations. But there are many factors that affect the distribution, complexity, make-up, and performance of ecosystems. Disturbance, pests, invasive species, deforestation, human management practices, overfishing, etc., are powerful influences on ecosystems. Climate change impacts are but one of many such features, and need to be considered in this broader context.

Attribution of ecosystem changes

It is important to note that the changes due to climate change occur against a background of rapid changes in other factors affecting ecosystems. These include changing patterns of land management, intensification of land use and exurban development, new management practices (e.g., biofuel production), species invasions and changing air quality (Lodge et al. 2006). Because many factors are affecting ecosystems simultaneously, it is difficult and in some cases impossible to factor out the magnitude of each impact separately. In a system affected by, for example, temperature, ozone, and changing precipitation, assigning a percentage of an observed change to each factor is generally impossible. Research on improving techniques for separating influences is ongoing, but in some cases drivers of change interact with each other, making the combined effects different from the sum of the separate effects. Scientific concern about such multiple stresses is rising rapidly.

Current Climate Change and the Future of Life on the Planet

Around 20,000 years ago, the last cooling phase ended, starting a warming period until around 8,000 years ago, during which Earth's average temperature rose between 5.6 and 8.5°F (3.1–4.7°C). This means a change of around 0.06°F (0.03°C) every century. Between 8,000 years ago and the Industrial Revolution (around 200 years ago), temperatures were relatively constant. Since then, temperatures have been increasing again, and very quickly .

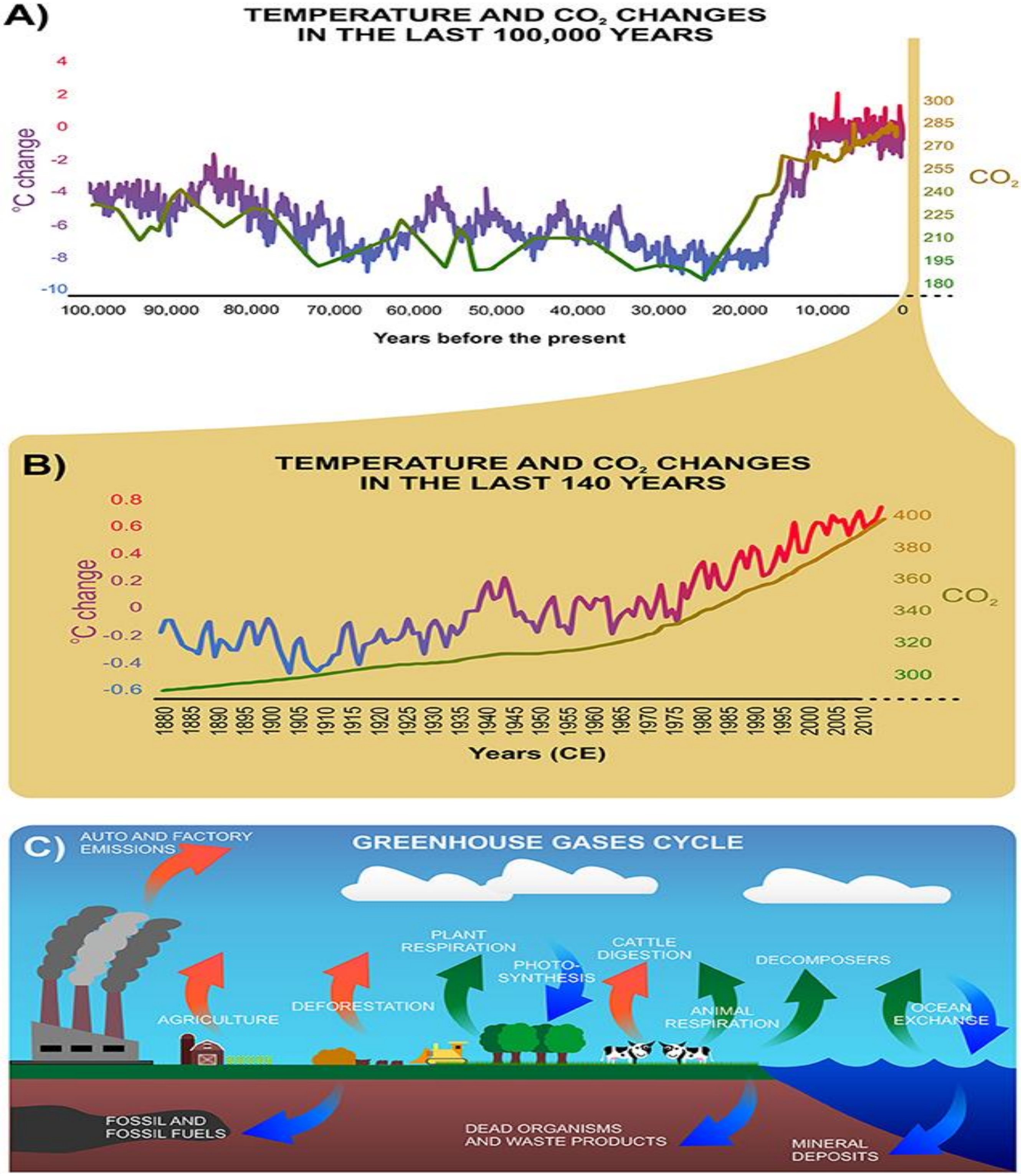


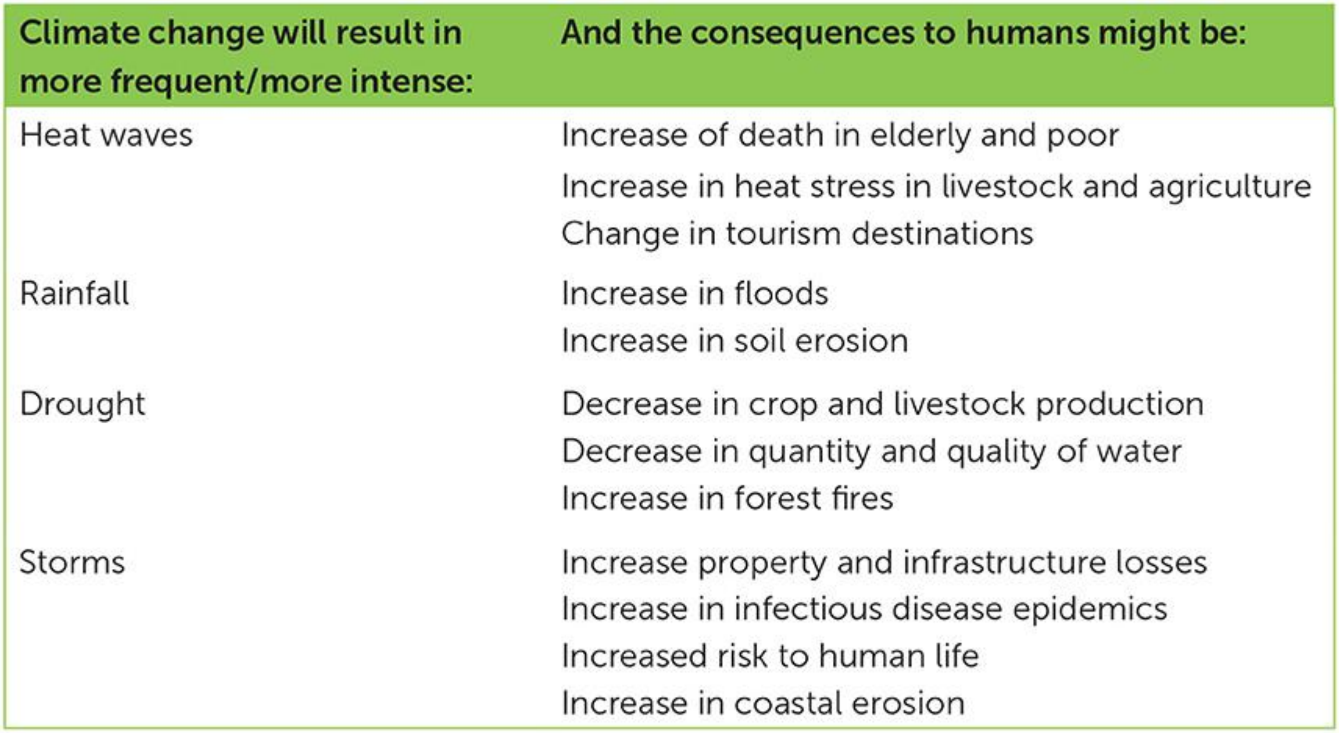
Figure 17 - **(A)** The changes in average temperature and CO_2 levels over the last 100,000 years. **(B)** The changes in average temperature and CO_2 levels between the years 1880 and 2016. In both (A, B), the blue-red line represents

temperature changes and the green-brown line represents CO_2 variation. From these graphs, you can clearly see that: (1) climate change and CO_2 variation are closely related; (2) climate has been changing over thousands of years; and (3) Earth is warming fast since 1880. **(C)** Greenhouse gases are gases capable of warming the Earth and the Atmosphere. Release of greenhouse gases into the atmosphere (upward arrows) and removal from the atmosphere (downward arrows) are shown. Red arrows represent anthropogenic-related emissions, and green arrows represent natural emissions (Data for A and B come from NASA, USA, and the National Oceanic and Atmospheric Administration, USA).

By 2100, scientists believe that the mean temperature on the planet will have raised an additional 3.6–8.8°F (2.0–4.9°C) compared with the temperatures at the time of the Industrial Revolution. This means that the planet's temperature rise in the next century will be about 100 times faster than what happened during the last 20,000 years (Bala et al.2007). While past changes in climate were the result of several factors, like the amount of energy coming from the sun and the concentration of different atmospheric gases, this time humans are mainly responsible. And that is why we call the current warming the anthropogenic (or human-induced) climate change (EPA 2002. 2006, Wang 1998).

Since the Industrial Revolution, our species has been burning immense amounts of fossil fuel to support our ever-growing demand for energy. Primarily through this activity, over the last 200 years, humans have increased the amount of carbon dioxide (CO_2) in the atmosphere by about 46%. And CO_2 is not the only factor affecting climate. The use of fossil fuels, agriculture, industrial processes, and deforestation emit other substances (or prevent them from naturally decreasing) that contribute to climate changes (Figure 17 A, B & C).

The anthropogenic climate change may not seem much to us now, but it will have a huge impact on humankind within the current and next few generations. The frequency and intensity of natural phenomena, like droughts and storms, will very likely increase with several consequences to humans (Table 1). Even our shorelines will dramatically change as the oceans rise, primarily due to the melting of the ice caps. This may result in the abandonment of entire coastal cities, like New York, Miami, Rio de Janeiro, Amsterdam, and Bangkok.

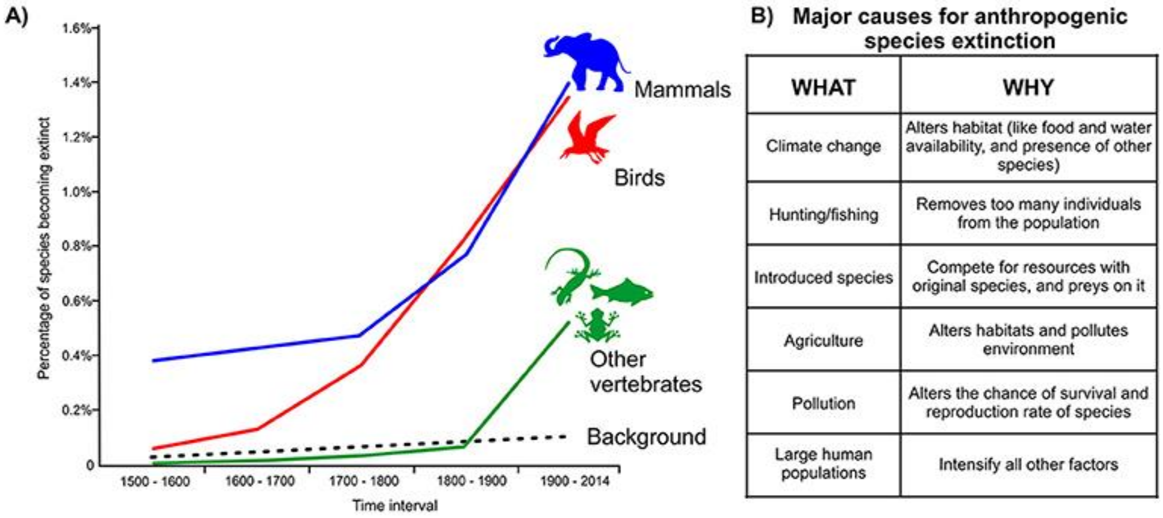


Climate change will result in more frequent/more intense:	And the consequences to humans might be:
Heat waves	Increase of death in elderly and poor Increase in heat stress in livestock and agriculture Change in tourism destinations
Rainfall	Increase in floods Increase in soil erosion
Drought	Decrease in crop and livestock production Decrease in quantity and quality of water Increase in forest fires
Storms	Increase property and infrastructure losses Increase in infectious disease epidemics Increased risk to human life Increase in coastal erosion

Table 2 - Major direct impacts on human lives due to the anthropogenic climate change (Information adapted from the Intergovernmental Panel on Climate Change).

Climate change will also affect life forms on the planet. Several microbes, plants, and animals will probably become extinct. Just to give you a glimpse of how life can change in response to climate change, only 6,000 years ago the Sahara Desert, one of the driest places on Earth today, was covered by lush vegetation.

Climate changes affect how living beings interact with each other and with the environment they live in. When faced with climate challenges, species have two main options (which can also happen in combination). The first is to migrate. For example, as the ocean surface temperatures increase due to the anthropogenic climate change, several species, from algae to fishes, are moving toward the poles in search of colder waters (Table 2).



B) Major causes for anthropogenic species extinction

WHAT	WHY
Climate change	Alters habitat (like food and water availability, and presence of other species)
Hunting/fishing	Removes too many individuals from the population
Introduced species	Compete for resources with original species, and preys on it
Agriculture	Alters habitats and pollutes environment
Pollution	Alters the chance of survival and reproduction rate of species
Large human populations	Intensify all other factors

Figure 18 - **(A)** Vertebrate extinction rates since the year 1500. The dotted line ("Background") represents the amount of extinction expected without human influence. You can see that the amount of extinctions caused by humans has increased over time, and is several times larger than the background extinction rate. **(B)** Major ways that human

When species cannot migrate or evolve in response to the changes in the environment, they become extinct. Human lifestyle and the rapidly increasing number of humans on the planet impose a series of challenges for the survival of several species (Figure 18A & B). Around two vertebrate species became extinct per year during the last 100 years, mainly due to human causes. Some examples of the many harmful byproducts of our lifestyle are the intense deforestation due to agriculture and the pollution of air and water. Anthropogenic climate change deserves special attention, because it is different from other human impacts. Anthropogenic climate change has a global effect, even on areas that are seldom disturbed by other human impacts, such as some protected areas. In addition, anthropogenic climate change is happening too quickly for several species to be able to migrate or evolve. This means that anthropogenic climate change is a serious threat to species that are already struggling to survive on an extensively human-transformed Earth. The take-home message here is: humans are causing a long-lasting and devastating impact on life on Earth. To put it in numbers, it is possible that over 75% of all species, three out of every four species that currently exist, will be extinct a few century.

Extinction of exquisite life forms is sad in itself, but the problem of extinction goes far beyond just the disappearance of these organisms. We rely on many of them to survive. The quality of the air we breathe, the water we drink, and the food we eat, just to name a few, are directly related to the existence and the health of several other species.

In addition, we also study other life forms to find solutions to our own problems. For instance, the hook-and-loop fastener was developed after studying the burrs (seeds) of a plant called burdock, which naturally attach to clothes. Several medicines have been discovered in different life forms and were only later synthesized in laboratories. There are countless inventions/discoveries waiting for us to find by studying nature, but they are only available while the species that can help us are still alive on the planet.

Be a part of the solution for Climate Change

All over the world, people are working together to lessen the effects of climate change and other negative human impacts on the planet. The Paris Agreement, which started in 2016, is a good example of this. This agreement is a global effort to prevent global temperatures from rising more than 3.6°F (2°C) in relation to the period before the Industrial Revolution. The basic idea is to drastically reduce global emissions of CO_2 and other substances that contribute to climate change. Currently, 185 countries out of almost 200 have joined in support of the Paris Agreement.

However, in a planet with over 7.6 billion people, we all need to change our ways of living to minimize anthropogenic climate change. There are many ways that each of us can do our part. A good first step is to calculate your family’s carbon footprint. The carbon footprint measures how much CO_2 we are emitting into the atmosphere over a certain period of time, the bright side is that there are also many simple ways to reduce our negative impact. Here are some easy things any of us can do to help prevent anthropogenic climate change. A few of these easy actions include: do not buy things you do not need, unplug appliances and turn off the lights you are not using, take shorter showers, eat less meat, poultry, and fish, shop locally and from sustainable sources, and use your bike or public transportation instead of a car whenever possible. Simple actions like these can make a big difference if enough of us perform them! We should all try to reduce our carbon footprints as much as we can, because we will then reduce our impact on anthropogenic climate change and the related negative consequences for life on Earth.

27. CONCLUSION

The changes in temperature and precipitation over the past century now form a persistent pattern and show features consistent with the scientific understanding of climate change. For example, scientists expect larger changes near the poles than near the equator. This pattern can be seen in the dramatically higher rates of warming in Alaska compared to the rest of the country. Most of the warming is concentrated in the last decades of the century. Prior to that, large natural variations due to solar and volcanic effects were comparable in magnitude to the then-lower greenhouse gas effects. These natural swings sometimes enhanced and sometimes hid the effects of greenhouse gases.

The warming due to greenhouse gases is now quite large and the “signal” of the greenhouse warming has more clearly emerged from the “noise” of the planet’s natural variations. The effects of greenhouse gases have slowly accumulated, but in the past few years, their effects have become evident. Recent data show clearly both the trends in climate, and climate’s effects on many aspects of the nation’s ecology. The changes that are likely to occur will continue to have significant effects on the ecosystems of the United States, and the services those ecosystems provide. The balance of this report will document some of the observed historical changes and provide insights into how the continuing changes may affect the nation’s ecosystems. The changes that are likely to occur will continue to have significant effects on the ecosystems of the United States, and the services those ecosystems provide.

Thus, the synthesis and assessment report builds on an extensive scientific literature and series of recent assessments of the historical and potential impacts of climate change and climate variability on managed and unmanaged ecosystems and their constituent biota and processes. It identifies changes in resource conditions that are now being observed, and examines whether these changes can be attributed in whole or part to climate change. It also highlights changes in resource conditions that recent scientific studies suggest are most likely to occur in response to climate change, and when and where to look for these changes.

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